2002P19552 WOUS

6

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 884 796 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
16.12.1998 Bulletin 1998/51

(51) Int. Cl.^{6}: **H01Q 1/36**, H01Q 9/42, H01Q 9/26

(21) Application number: 98110723.8

(22) Date of filing: 10.06.1998

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 11.06.1997 JP 153205/97
30.07.1997 JP 204019/97

(71) Applicant:
Matsushita Electric Industrial Co., Ltd.
Kadoma-shi, Osaka 571-0050 (JP)

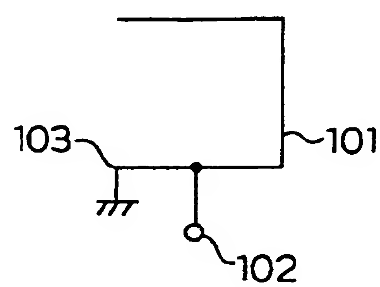
(72) Inventors:
- Kane, Joji
Nara-shi, Nara 631-0804 (JP)
- Yosida, Takasi
Ikoma-shi, Nara 630-0213 (JP)
- Nomura, Noboru
Kyoto-shi, Kyoto 612-0889 (JP)

(74) Representative:
Grünecker, Kinkeldey,
Stockmair & Schwanhäusser
Anwaltssozietät
Maximilianstrasse 58
80538 München (DE)

(54) **Antenna device consisting of bent or curved portions of linear conductor**

(57) An antenna device has at least one linear conductor each having one or more bent or curved portions for a feeder section.

Fig. 1 (a)



EP 0 884 796 A2

Description

BACKGROUND OF THE INVENTION

1.Field of the Invention

The present invention relates to an antenna device, for example, AM broadcasting, FM broadcasting, TV broadcasting or wireless telephone, etc., which is particularly attached to a body of an automobile, etc.

2.Related Art of the Invention

With the development of car multimedia times, in the recent years, not only AM/FM radio but also various radio units such as TV, a radio telephone or a navigation system are being mounted also on an automobile, and it is expected that, in the future, information and service which are supplied by radio waves are more and more increased so that the importance of the antenna is more and more heightened.

In general, in the case of equipping an automobile or the like with an antenna, a car body formed of a conductive base plate adversely affects the performance of the antenna such as a directional gain. Conventionally, considering that the antenna is installed to a car body, for example, a monopole, a rod antenna, a V dipole antenna or the like are employed as the antenna used for the automobile. Most of those antennas are provided so as to project a long bar-shaped antenna element from the car body.

However, as described above, the antenna provided so as to project from the car body the long bar-shaped antenna element or the like which is generally used for the automobile suffers from various problems such that not only the beauty of the appearance is lost, but also wind sound occurs, there is a risk that the antenna is robbed, the antenna must be removed when washing the automobile, and so on.

SUMMARY OF THE INVENTION

The present invention has been made to eliminate the above problems with the conventional antennas, and therefore an object of the present invention is to provide an antenna device which is capable of being equipped in the vicinity of a body of an automobile or being integrated with the body so as to be equipped on a plane and also capable of being downsized so an to be equipped even in a small location.

In order to achieve the above object, according to one aspect of the present invention, an antenna device includes at least one linear conductor each having at least one bent or curved portion for a feeder section.

According to another aspect of the present invention, in the above antenna device, the linear conductor has four or more even numbers of bent or curved portions.

According to further aspect of the present invention, the above antenna device includes at least one or more spiral linear conductor for the feeder section.

The above structure enables the antenna to be disposed within a slender casing.

According to further aspect of the present invention, an antenna device is disposed in the vicinity of a conductive base plate so that an earth terminal of the antenna is connected to the conductive base plate.

The above structure enables to obtain desired impedance characteristic and directivity.

According to still another aspect of the present invention, an antenna device is disposed in the vicinity of a conductive base plate, and a switching device is disposed between an earth terminal of the antenna and the conductive base plate.

The above structure enables to select desired impedance characteristic and directivity.

According to still another aspect of the present invention, an antenna device includes an antenna formed of an antenna element group into which a plurality of antenna elements are unified by a single feeder section.

The above structure enables to realize an antenna small in size and high in gain covers a desired frequency band.

According to still another aspect of the present invention, an antenna device includes an antenna formed of an antenna element group in which taps are formed at predetermined positions of a plurality of antenna elements, respectively, and those taps are joined together to form a single feeder section.

The above structure enables to realize an antenna small in size and high in gain which covers a desired frequency band by an easy feeding method.

According to still another aspect of the present invention, in an antenna device, tuning frequency is controlled by setting the coupling of opposed open terminal portions of an antenna element.

According to still another aspect of the present invention, in an antenna device, a tuning frequency is controlled by setting the coupling of an open terminal of an antenna element and a neutral point thereof or opposed portions thereof in the vicinity of the neutral point.

According to yet another aspect of the present invention, in an antenna device, at least one linear conductor is connected to both poles of a coil, respectively, and an earth terminal is formed at the neutral point of the coil, and a tap is formed at a predetermined position of the respective linear conductors or the coil, from which a feeding terminal is led out.

According to yet another aspect of the present invention, in an antenna device, one or more linear conductors are provided for a feeder section through a coil.

According to still another aspect of the present invention, in the above antenna device, at least one antenna is selected from a plurality of antennas under

control.

According to yet another aspect of the present invention, in the above antenna device, an antenna maximum in a receiver input is selected under control in the control for selecting a plurality of antennas.

According to still another aspect of the present invention, in the antenna device as defined in the above, an antenna minimum in multi-pass interference level is selected under control in the control for selecting a plurality of antennas.

According to yet another aspect of the present invention, in the antenna device as defined in the above, the antenna element is disposed in a recess of the conductive base plate.

According to still another aspect of the present invention, an antenna device is comprised of: a main antenna element a predetermined portion of which is grounded; at least one antenna element which is disposed close to the main antenna element, which is relatively shorter than the main antenna element, and both ends of which are not grounded; and at least one antenna element which is disposed closed to the main antenna element, which is relatively longer than the main antenna element, and both ends of which are not grounded.

According to yet another aspect of the present invention, an antenna device is comprised of: a conductive base plate; and an antenna element, an earth portion of which is connected to the conductive base plate and disposed close to the conductive base plate, wherein at least a region of the conductive base plate which is opposed to the antenna element is disposed on a communication counterpart side with respect to the antenna element.

According to still another aspect of the present invention, an antenna device is comprised of: a conductive base plate; a plurality of antenna elements, an earth portion of which is connected to the conductive base plate, which are disposed close to the conductive base plate in correspondence with the tuning frequencies of plural bands, and which is different in length from each other; and a plurality of feeder sections disposed on each of the plurality of antenna elements.

According to yet another aspect of the present invention, an antenna device is comprised of: a conductive base plate; and an antenna element disposed close to the conductive base plate; wherein a predetermined portion of the antenna element is formed of a coil or zigzag-shaped conductor; and wherein one end of the antenna element is grounded to the conductive base plate.

According to still another aspect of the present invention, an antenna device is comprised of: a conductive base plate; and at least two antenna elements which are disposed close to the conductive base plate and different in length from each other; wherein the respective predetermined portions of the antenna elements are formed of coil or zigzag-shaped conductor; and wherein the respective one ends of the antenna elements are commonly grounded to the conductive base plate.

The above structure enables to further reduce the size of the antenna device without changing a gain.

According to yet another aspect of the present invention, in an antenna device, an antenna element is wholly formed of a coil or zigzag-shaped conductor and formed in a shape having at least one bent or curved portion.

The above structure further reduces the antenna device in size.

According to yet another aspect of the present invention, an antenna device is comprised of: a conductive base plate; and an antenna element one end of which is grounded to the conductive base plate and which is disposed close to the conductive base plate; wherein a feeder section is connected to an insulator disposed on the conductive base plate as a junction point.

The above and other objects and features of the present invention will be more apparent from the following description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIGS. 1(a) and 1(b) are schematic diagrams showing examples of an antenna device according to a first embodiment of the present invention;

FIGS. 2(a) and 2(b) are schematic diagrams showing other examples of an antenna device according to the first embodiment of the present invention;

FIGS. 3(a) and 3(b) are schematic diagrams showing examples of an antenna device according to a second embodiment of the present invention;

FIGS. 4(a) and 4(b) are schematic diagrams showing other examples of an antenna device according to the second embodiment of the present invention;

FIGS. 5(a) and 5(b) are schematic diagrams showing examples of an antenna device according to a third embodiment of the present invention;

FIGS. 6(a) and 6(b) are schematic diagrams showing other examples of an antenna device according to the third embodiment of the present invention;

FIGS. 7(a) and 7(b) are schematic diagrams showing other examples of an antenna device according to the third embodiment of the present invention;

FIGS. 8(a) and 8(b) are schematic diagrams showing other examples of an antenna device according to the third embodiment of the present invention;

FIGS. 9(a) and 9(b) are schematic diagrams showing examples of an antenna device according to a fourth embodiment of the present invention;

FIGS. 10(a) and 10(b) are schematic diagrams showing other examples of an antenna device

according to the fourth embodiment of the present invention;

FIGS. 11(a) and 11(b) are schematic diagrams showing other examples of an antenna device according to the fourth embodiment of the present invention;

FIGS. 12(a) and 12(b) are schematic diagrams showing other examples of an antenna device according to the fourth embodiment of the present invention;

FIGS. 13(a) and 13(b) are schematic diagrams showing examples of an antenna device according to a fifth embodiment of the present invention;

FIGS. 14(a) and 14(b) are schematic diagrams showing other examples of an antenna device according to the fifth embodiment of the present invention;

FIG. 15 is a schematic diagram showing examples of an antenna device according to a sixth embodiment of the present invention;

FIGS. 16(a) and 16(b) are schematic diagrams showing other examples of an antenna device according to the sixth embodiment of the present invention;

FIGS. 17(a) and 17(b) are schematic diagrams showing other examples of an antenna device according to the sixth embodiment of the present invention;

FIGS. 18(a) and 18(b) are schematic diagrams showing other examples of an antenna device according to the sixth embodiment of the present invention;

FIGS. 19(a) and 19(b) are schematic diagrams showing examples of an antenna device according to a seventh embodiment of the present invention;

FIGS. 20(a) and 20(b) are schematic diagrams showing other examples of an antenna device according to the seventh embodiment of the present invention;

FIGS. 21(a) and 21(b) are schematic diagrams showing other examples of an antenna device according to the seventh embodiment of the present invention;

FIGS. 22(a) and 22(b) are schematic diagrams showing examples of an antenna device according to an eighth embodiment of the present invention;

FIG. 23 is a schematic diagram showing another example of an antenna device according to the eighth embodiment of the present invention;

FIGS. 24(a) and 24(b) are diagrams showing positional relationships between an antenna and a conductive base plate in the antenna device according to the eighth embodiment of the present invention;

FIGS. 25(a) and 25(b) are schematic diagrams showing examples of an antenna device according to a ninth embodiment of the present invention;

FIGS. 26(a) and 26(b) are schematic diagrams showing examples of an antenna device according to a tenth embodiment of the present invention;

FIGS. 27(a) and 27(b) are schematic diagrams showing examples of an antenna device according to an eleventh embodiment of the present invention;

FIGS. 28(a) and 28(b) are schematic diagrams showing other examples of an antenna device according to the eleventh embodiment of the present invention;

FIG. 29 is a schematic diagram showing an example of an antenna device according to a twelfth embodiment of the present invention;

FIGS. 30(a) to 30(c) are schematic diagrams showing examples of an antenna device according to a thirteenth embodiment of the present invention;

FIGS. 31(a) to 31(c) are schematic diagrams showing examples of an antenna device according to a fourteenth embodiment of the present invention;

FIGS. 32(a) and 32(b) are schematic diagrams showing examples of an antenna device according to a fifteenth embodiment of the present invention;

FIGS. 33(a) and 33(b) are schematic diagrams showing other examples of an antenna device according to the fifteenth embodiment of the present invention;

FIG. 34 is a schematic diagram showing an example of an antenna device according to a sixteenth embodiment of the present invention;

FIG. 35 is a schematic diagram showing an example of an antenna device according to a seventeenth embodiment of the present invention;

FIG. 36 is a perspective view for explanation of an example of a location where an antenna device is equipped according to an eighteenth embodiment of the present invention;

FIGS. 37(a) and 37(b) are perspective views for explanation of other examples of a location where an antenna device is equipped according to the eighteenth embodiment of the present invention;

FIG. 38 is a schematic diagram showing an example of a mobile communication apparatus having an antenna device according to a nineteenth embodiment of the present invention;

FIGS. 39(a) and 39(b) are schematic diagrams showing examples of a portable telephone having an antenna device according to a twentieth embodiment of the present invention;

FIG. 40 is a diagram showing an example of the composition of frequency bands according to the present invention;

FIG. 41 is a diagram showing an example of a gain accumulation according to the present invention;

FIGS. 42(a) and 42(b) are schematic structural diagrams showing an antenna device according to a twenty-first embodiment of the present invention;

FIGS. 43(a) and 43(b) are schematic diagrams showing other examples of an antenna device according to the twenty-first embodiment of the

present invention;

FIGS. 44(a) and 44(b) are schematic diagrams showing an antenna device according to a twenty-second embodiment of the present invention;

FIGS. 45(a) and 45(b) are schematic diagrams showing examples of an antenna device according to a twenty-third embodiment of the present invention;

FIG. 46 is a schematic diagram showing an example of an antenna device according to a twenty-fourth embodiment of the present invention;

FIG. 47 is a perspective view showing an example in which an antenna device is applied to a car body according to a twenty-fifth embodiment of the present invention;

FIG. 48 is a perspective view showing an example in which locations where an antenna is equipped are applied to the respective parts of a car body according to a twenty-sixth embodiment of the present invention;

FIGS. 49(a) and 49(b) are diagrams for explanation of the properties of an antenna according to the twenty-sixth embodiment of the present invention;

FIGS. 50(a) to 50(c) are schematic diagrams showing the structures of an antenna according to a twenty-seventh embodiment of the present invention;

FIGS. 51(a) to 51(c) are schematic diagrams showing other structures of an antenna according to the twenty-seventh embodiment of the present invention;

FIG. 52 is a perspective view showing an example in which locations where an antenna is equipped are applied to the respective parts of a car body according to the twenty-seventh embodiment of the present invention;

FIG. 53 is a perspective view showing an example in which an antenna is applied to a portable telephone according to the twenty-seventh embodiment of the present invention;

FIG. 54 is a perspective view showing an example in which an antenna is applied to a general house according to the twenty-seventh embodiment of the present invention;

FIGS. 55(a) and 55(b) are schematic diagrams showing the structure of an antenna according to a twenty-eighth embodiment of the present invention;

FIG. 56(a) is a schematic diagram showing another example of the structure of an antenna according to the twenty-eighth embodiment of the present invention, and FIG. 56(b) is a diagram for explanation of the structure shown in FIG. 56(a);

FIGS. 57(a) to 57(c) are diagrams showing examples of the structure of an antenna according to a twenty-ninth embodiment of the present invention;

FIGS. 58(a) to 58(c) are schematic diagrams showing other examples of the structure of an antenna according to the twenty-ninth embodiment of the present invention;

FIGS. 59(a) and 59(b) are schematic diagrams showing still other examples of the structure of an antenna according to the twenty-ninth embodiment of the present invention;

FIGS. 60(a) and 60(b) are schematic diagrams showing an example of the structure of an antenna according to a thirtieth embodiment of the present invention, and FIG. 60(c) is a diagram for explanation of its frequency characteristic;

FIGS. 61(a) and 61(b) are schematic diagrams showing another example of the structure of an antenna according to the thirtieth embodiment of the present invention, and FIG. 61(c) is a diagram for explanation of its frequency characteristic;

FIGS. 62(a) and 62(b) are schematic diagrams showing still another example of the structure of an antenna according to the thirtieth embodiment of the present invention, and FIG. 62(c) is a diagram for explanation of its frequency characteristic;

FIG. 63 is a diagram showing an applied example of an antenna device according to the twenty-ninth embodiment of the present invention;

FIG. 64 is a diagram showing another applied example of an antenna device according to the twenty-ninth embodiment of the present invention;

FIG. 65 is a diagram showing still another applied example of an antenna device according to the twenty-ninth embodiment of the present invention;

FIG. 66 is a diagram showing yet still another applied example of an antenna device according to the twenty-ninth embodiment of the present invention;

FIG. 67 is a schematic diagram showing an example of the structure of an antenna according to a thirty-first embodiment of the present invention;

FIG. 68 is a schematic diagram showing another example of the structure of an antenna according to the thirty-first embodiment of the present invention;

FIG. 69 is a schematic diagram showing an example of the structure of an antenna according to a thirty-second embodiment of the present invention;

FIG. 70 is a schematic diagram showing another example of the structure of an antenna according to the thirty-second embodiment of the present invention;

FIG. 71 is a schematic diagram showing an example of the structure of an antenna according to a thirty-third embodiment of the present invention;

FIG. 72 is a schematic diagram showing another example of the structure of an antenna according to the thirty-third embodiment of the present invention;

FIG. 73 is a schematic diagram showing an example of the structure of an antenna according to a thirty-fourth embodiment of the present invention;

FIG. 74 is a schematic diagram showing another example of the structure of an antenna according to the thirty-fourth embodiment of the present inven-

tion;

FIG. 75 is a schematic diagram showing an example of the structure of an antenna according to a thirty-fifth embodiment of the present invention;

FIG. 76 is a schematic diagram showing another example of the structure of an antenna according to the thirty-fifth embodiment of the present invention;

FIG. 77 is a schematic diagram showing an example of the structure of an antenna according to a thirty-sixth embodiment of the present invention;

FIGS. 78(a) to 78(c) are schematic diagrams showing other examples of a pattern according to the thirty-sixth embodiment of the present invention;

FIG. 79 is a schematic diagram showing an example of the structure of an antenna according to a thirty-seventh embodiment of the present invention;

FIG. 80 is a schematic diagram showing another example of the structure of an antenna according to the thirty-seventh embodiment of the present invention;

FIG. 81 is a schematic diagram showing still another example of the structure of an antenna according to the thirty-seventh embodiment of the present invention;

FIG. 82 is a schematic diagram showing yet still another example of the structure of an antenna according to the thirty-seventh embodiment of the present invention;

FIG. 83 is a schematic diagram showing an example of the structure of an antenna according to a thirty-eighth embodiment of the present invention; and

FIG. 84 is a schematic diagram showing an example of the structure of an antenna according to a thirty-ninth embodiment of the present invention.

FIG. 85 is a perspective diagram showing a concrete structure of the antenna device of FIG. 2.

FIGS. 86 (a) and (b) show an impedance characteristics and VSWR of the antenna of FIG. 85.

FIG. 87 shows a directional gain performance of the antenna of FIG. 85.

FIG. 88 shows VSWR of one element for explaining the Band composition of four antenna element.

FIG. 89 shows VSWR of another element for explaining the band composition of four antenna element.

FIG. 90 shows VSWR of another element for explaining the band composition of four antenna element.

FIG. 91 shows VSWR of another element for explaining the band composition of four antenna element.

FIG. 92 shows VSWR in case of band composition of four elements of FIG. 88 to FIG. 91.

FIG. 93 shows a graph of VSWR wherein the longitudinal axis is extended against the FIG. 92.

FIGs. 94 (a), (b), (c) and (d) show a directional gain performance when the separate distance between the antenna earth and device earth in FIG. 44(b).

FIG. 95 shows a directional gain performance of the antenna of FIG. 55(a).

FIG. 96 shows a directional gain performance of the antenna of FIG. 55(b).

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, a description will be given in more detail based on embodiments of the present invention with reference to the accompanying drawings.

First, a principle of the present invention will be described. As described in the above "Description of the Related Art", in the conventional antenna, in the case where the antenna is disposed close to the conductive base plate, a car body that is formed of the conductive base plate affects the antenna performance such as the directional gain as in the monopole antenna. The present invention is designed to realize an antenna which provides non-directivity, improves the directional gain, and obtains a high selectivity utilizing the effect on the antenna of the conductive base plate adversely.

(Embodiment 1)

FIGS. 1(a) and 1(b) are schematic diagrams showing examples of an antenna device according to a first embodiment of the present invention. That is, FIG. 1(a) shows an antenna device in which an antenna element 101 is formed of a linear conductor having two bent portions, a feeding terminal 102 is disposed at a predetermined position of the antenna element 101, and one end portion 103 of the antenna element 101 in grounded. Also, FIG. 1(b) shows an antenna device in which an antenna element 104 is formed of a linear conductor having four bent portions, a feeding terminal 102 is disposed at a predetermined position of the antenna element 104, and one end portion 103 of the antenna element 104 is grounded. In this way, the antenna device according to this embodiment can reduce an equipment area since the antenna element of the monopole antenna is bent.

FIGS. 2(a) and 2(b) are schematic diagrams showing other examples in which an antenna device having the same structure as that of the above antenna device is disposed close to a conductive base plate. That is, FIG. 2(a) shows an antenna device in which an antenna element 201 is formed of a linear conductor having two bent portions, the antenna element 201 is disposed close to a conductive base plate 205 in such a manner that an antenna plane is in parallel with the conductive base plate 205, a feeding terminal 202 is disposed at a predetermined position of the antenna element 201, and one end portion 203 of the antenna element 201 is grounded to the conductive base plate 205. Also, FIG. 2(b) shows an antenna device in which an antenna element 204 is formed of a linear conductor having four

bent portions, the antenna element 204 is disposed close to a conductive base plate 205 in such a manner that an antenna plane is in parallel with the conductive base plate 205, a feeding terminal 202 is disposed at a predetermined position of the antenna element 204, and one end portion 203 of the antenna element 204 is grounded to the conductive base plate 205. In this way, the antenna device according to this embodiment can reduce an equipment area, and also improves the directional gain performance since the antenna device according to the above-described first embodiment is disposed close to the conductive base plate 205 in such a manner that the antenna plane is in parallel with the conductive base plate 205. It should be noted that the number of bent portions of the antenna element is not limited to or by the number described in the above examples. The same is also applied to the following embodiments.

The concrete example of the antenna of FIG.2(a) is shown in FIG. 85. In FIG.85 an antenna element 8501 of a linear conductor having two bent portions has such constitution that an antenna plane is disposed in parallel with a conductive base plate 8504 with certain space and an one edge of the antenna element 8501 is connected to one edge of a conductive plate 8503 which earthes the antenna element 8501 and is provided vertical to the conductive base plate 8504. In this embodiment the area of a plane formed by the antenna element 8501 is substantially equal to the area of the conductive base plate 8504. There is a feeding terminal 8502 in the way of the antenna element 8501.

The conductive plate 8503 has enough width against the width of the antenna element 8501. That is the plate 8503 has such wide width so that it is not effected on practical use by the reactance determined by a tuning frequency of the antenna element 8501. As the result the plate 8503 serves as an earth. If the width is not enough the plate 8503 is integrated with the antenna element 8503 so that antenna element 8501 and the plate 8503 becomes an antenna element as a whole which is different from the present invention. When the wave length is 940 mm, whole length of the antenna element 8501 is 220 mm and the width is 2 mm and these are compact sizes. The plane of the antenna element 8501 can be inclined against the conductive base plate 8504 so far as the useful voltage is generated between the antenna element 8501 and the base plate 8504. When the area of the base plate 8504 is larger for example four times than the area of the antenna plane, the gain is same for vertical polarization wave and the gain becomes less for horizontal polarization wave.

The difference between the embodiment and the prior antenna is that for example the capability of prior reverse F antenna becomes inferior when an antenna element becomes near to the ground plate however the capability of the embodiment becomes superior on the contrary.

FIG.86 shows the impedance characteristics and the VSWR characteristics of the antenna of FIG. 85. FIG. 87 shows the directional gain performance. As shown FIG. 87 the antenna of FIG. 85 has nearly circle shape directional gain performance against a vertical polarization wave.

Now the number or shape of the antenna is not restricted by such embodiment.

The distance between the base palate and the antenna element is preferably 1/40 of wave length or more.

(Embodiment 2)

FIGS. 3(a) and 3(b) are schematic diagrams showing examples of an antenna device according to a second embodiment of the present invention. That is, FIG. 3(a) shows an antenna device in which an antenna element 301 is formed of a linear conductor having four bent portions to constitute a dipole antenna, a feeding terminal 302 is disposed at a predetermined position of the antenna element 301, and one end portion 303 of the antenna element 301 is grounded. Also, FIG. 3(b) shows an antenna device in which an antenna element 304 is formed of a linear conductor having eight bent portions to constitute a dipole antenna, a feeding terminal 302 is disposed at a predetermined position of the antenna element 304, and one end portion 303 of the antenna element 304 is grounded. In this way, the antenna device according to this embodiment can reduce an equipment area since the antenna element of the dipole antenna is bent so as to be wound.

FIGS. 4(a) and 4(b) are schematic diagrams showing other examples in which an antenna device having the same structure as that of the above antenna device is disposed close to a conductive base plate, respectively. That is, FIG. 4(a) shows an antenna device in which an antenna element 401 is formed of a linear conductor having four bent portions to constitute a dipole antenna, the antenna element 401 is disposed close to a conductive base plate 405 in such a manner that an antenna plane is in parallel with the conductive base plate 405, a feeding terminal 402 is disposed at a predetermined position of the antenna element 401, and one end portion 403 of the antenna element 401 is grounded to the conductive base plate 405. Also, FIG. 4(b) shows an antenna device in which an antenna element 404 is formed of a linear conductor having eight bent portions to constitute a dipole antenna, the antenna element 404 is disposed close to a conductive base plate 405 in such a manner that an antenna plane is in parallel with the conductive base plate 405, a feeding terminal 402 is disposed at a predetermined position of the antenna element 401, and one end portion 403 of the antenna element 404 is grounded to the conductive base plate 405. In this way, the antenna device according to this embodiment can reduce an equipment area, and also improves the directional gain performance in

the case where the antenna device is disposed close to the conductive base plate 405 in such a manner that the antenna plane is in parallel with the conductive base plate 405.

(Embodiment 3)

FIGS. 5(a) and 5(b) are schematic diagrams showing examples of an antenna device according to a third embodiment of the present invention. That is, FIG. 5(a) shows an antenna device which is structured in such a manner that three monopole antenna elements 501a, 501b and 501c each having two bent portions and being different in element length from each other are disposed on the same plane, reactance elements 502a, 502b, 502c and 504 are connected between the taps of the antenna elements 501a, 501b and 501c and a feeding terminal 503 and between the feeding terminal 503 and an earth terminal 505 to adjust an impedance, respectively. Also, FIG. 5(b) shows an antenna device in which the antenna elements 501a, 501b and 501c of the above antenna device shown in FIG. 5(a) are changed to antenna elements 506a, 506b and 506c having four bent portions.

In the above structure, the tuning frequencies of the respective antenna elements are set at given intervals, thereby being capable of realizing an antenna device having a desired frequency band. FIG. 40 is a diagram showing the composed frequency bands in case of an antenna having seven antenna elements, in which the frequency band width of one antenna element is narrow, but the frequency characteristic of a wide frequency band can be provided by composing the respective frequency band widths.

The concrete embodiments of such band composing are shown by VSWR characteristics in FIGS. 88 to 93. It is examples using four antenna elements which have different tuning frequencies of 196.5MHZ(FIG.88),198.75MHZ(FIG.89),200.5MHZ(FIG.90),2 03.75MHZ(FIG.91). FIG. 92 shows the VSWR when such antenna elements are composed with band. This shows wide band composing. FIG. 93 shows five times extended graph on longitudinal axis for the FIG. 92.

FIGS. 6(a) and 6(b) are schematic structural diagrams showing examples in which an antenna device having the same structure as that of FIG. 5(a) or 5(b) is disposed close to a conductive base plate, respectively. These antenna devices are structured in such a manner that the antenna device having the same structure as that of FIG. 5(a) or 5(b) is disposed close to a conductive base plate 607 so that an antenna plane is in parallel with the conductive base plate 607. That is, FIG. 6(a) shows an antenna device which is structured in such a manner that three monopole antenna elements 601a, 601b and 601c each having two bent portions and being different in element length from each other are disposed on the same plane so as to be close to the conductive base plate 607, reactance elements 602a, 602b, 602c and 604 are connected between the taps of the antenna elements 601a, 601b and 601c and a feeding terminal 603 and between the feeding terminal 603 and an earth terminal 605 to adjust an impedance, respectively. Also, FIG. 6(b) shows an antenna device in which the antenna elements 601a, 601b and 601c of the above antenna device shown in FIG. 6(a) are changed to antenna elements 606a, 606b and 606c having four bent portions.

FIGS. 7(a) and 7(b) are schematic diagrams showing other examples of an antenna device according to this embodiment. That is, FIG. 7(a) shows the structure of an antenna device having the same structure as that of FIG. 5(a) as described above, in which frequency band composing reactance elements 708a and 708b are disposed between the respective antenna elements 701a, 701b and 701c. Also, FIG. 7(b) shows the structure of an antenna device having the same structure as that of FIG. 5(b) as described above, in which frequency band composing reactance elements 708a and 708b are disposed between the respective antenna elements 706a, 706b and 706c. In the structures of FIGS. 5(a) and 5(b), the respective reactance elements 502a, 502b and 502c are also used to compose the frequency bands. On the other hand, in this embodiment, the adjustment of impedance and the adjustment of frequency composition are liable to be implemented because the function of composing the frequency bands is separated.

FIGS. 8(a) and 8(b) are schematic diagrams showing still other examples of an antenna device according to this embodiment. These antenna devices are structured in such a manner that an antenna device having the same structure as that of FIG. 7(a) or 7(b) is disposed close to a conductive base plate 807 so that an antenna plane is in parallel with the conductive base plate 807. That is, FIG. 8(a) shows the structure of an antenna device having the same structure as that of FIG. 6(a) as described above, in which frequency band composing reactance elements 808a and 808b are disposed between the respective antenna elements 801a, 801b and 801c. Also, FIG. 8(b) shows the structure of an antenna device having the same structure as that of FIG. 6(b) as described above, in which frequency band composing reactance elements 808a and 808b are disposed between the respective antenna elements 806a, 806b and 806c.

(Embodiment 4)

FIGS. 9(a) and 9(b) are schematic diagrams showing an antenna device according to a fourth embodiment of the present invention. That is, FIG. 9(a) shows an antenna device which is structured in such a manner that three dipole antenna elements 901a, 901b and 901c each having four bent portions and being different in element length from each other are disposed on the

same plane, reactance elements 902a, 902b, 902c and 904 are connected between the taps of the antenna elements 901a, 901b and 901c and a feeding terminal 903 and between the feeding terminal 903 and an earth terminal 905 to adjust an impedance, respectively. Also, FIG. 9(b) shows an antenna device in which the antenna devices 901a, 901b and 901c of the above antenna device shown in FIG. 9(a) are changed to antenna elements 906a, 906b and 906c having eight bent portions.

In the above structure, the tuning frequencies of the respective antenna elements are set at given intervals, thereby being capable of realizing an antenna device having a desired frequency band.

FIGS. 10(a) and 10(b) are schematic diagrams showing other examples of an antenna device according to this embodiment. These antenna devices are structured in such a manner that an antenna device having the same structure as that of FIG. 9(a) or 9(b) is disposed close to a conductive base plate 1007 so that an antenna plane is in parallel with the conductive base plate 1007. That is, FIG. 10(a) shows an antenna device which is structured in such a manner that three dipole antenna elements 1001, 1002 and 1003 each having four bent portions and being different in element length from each other are disposed on the same plane so as to be close to a conductive base plate 1007, reactance elements 1004, 1005, 1006 and 1009 are connected between the taps of the antenna elements 1001, 1002 and 1003 and a feeding terminal 1008 and between the feeding terminal 1008 and an earth terminal 1010 to adjust an impedance, respectively. Also, FIG. 10(b) shows an antenna device in which the antenna devices 1001, 1002 and 1003 of the above antenna device shown in FIG. 10(a) are changed to antenna elements 1011, 1012 and 1013 having eight bent portions.

FIGS. 11(a) and 11(b) are schematic structural diagrams showing still other examples of an antenna device according to this embodiment. That is, FIG. 11(a) shows the structure of an antenna device having the same structure as that of FIG. 9(a) as described above, in which frequency band composing reactance elements 1114, 1115, 1116 and 1117 are disposed separately at two locations between the respective antenna elements 1101, 1102 and 1103. Also, FIG. 11(b) shows the structure of an antenna device having the same structure as that of FIG. 9(b) as described above, in which frequency band composing reactance elements 1114, 1115, 1116 and 1117 are disposed separately at two locations between the respective antenna elements 1111, 1112 and 1113. In the structures of FIGS. 9(a) and 9(b), the respective reactance elements 902a, 902b and 902c are also used to compose the frequency bands. On the other hand, in this embodiment, the adjustment of impedance and the adjustment of frequency composition are liable to be implemented because the function of composing the frequency bands is separated.

FIGS. 12(a) and 12(b) are schematic structural diagrams showing still other examples of an antenna device according to this embodiment. These antenna devices are structured in such a manner that an antenna device having the same structure as that of FIG. 11(a) or 11(b) is disposed close to a conductive base plate 1207 so that an antenna plane is in parallel with the conductive base plate 1207. That is, FIG. 12(a) shows the structure of an antenna device having the same structure as that of FIG. 10(a) as described above, in which frequency band composing reactance elements 1214, 1215, 1216 and 1217 are disposed separately at two locations between the respective antenna elements 1201, 1202 and 1203. Also, FIG. 12(b) shows the structure of an antenna device having the same structure as that of FIG. 10(b) as described above, in which frequency band composing reactance elements 1214, 1215, 1216 and 1217 are disposed separately at two locations between the respective antenna elements 1211, 1212 and 1213.

(Embodiment 5)

FIGS. 13(a) and 13(b) are schematic structural diagrams showing antenna devices according to a fifth embodiment of the present invention. That is, FIG. 13(a) shows an antenna device in which the respective antenna elements 1301, 1302 and 1303 of three dipole antennas different in element length from each other are formed on a printed board 1304. Also, FIG. 13(b) shows an antenna device in which a conductive base plate 1308 is formed in the same structure as that of FIG. 13(a) as described above, on a surface of the printed board 1304 opposite to the antenna element 1320. In this way, with the structure where the antenna elements 1301, 1302 and 1303 (1305, 1306 and 1307) and the conductive base plate 1308 are formed using the printed board, a space occupied by the antenna can be saved, the manufacture is simplified, and the reliability and stability of performance are also improved.

FIGS. 14(a) and 14(b) are schematic structural diagrams showing other examples of an antenna device according to this embodiment. Those antenna devices are structured such that in the same structure as that of FIG. 13(a) as described above, a conductor for composing the frequency bands is formed on a surface of the printed board opposite to the antenna elements so as to cross the antenna elements. That is, FIG. 14(a) shows an antenna device in which the respective antenna elements 1401, 1402 and 1403 of three dipole antennas different in element length from each other are formed on a printed board 1404, and two conductors 1405 are formed on a surface of the printed board 1404 opposite to the surface on which the antenna element 1410 is disposed, so as to cross the antenna element. Also, FIG. 14(b) shows an antenna device in which a conductive base plate 1406 is closely formed at an opposite side of the antenna element 1410 in the antenna device

having the same structure as that of FIG. 14(a) as described above. The conductive base plate 1406 may be formed on the printed board using a multi-layer printed board The above structure facilitates the manufacture of the frequency band composing element.

(Embodiment 6)

FIGS. 15(a) and 15(b) are schematic diagrams showing antenna devices according to a sixth embodiment of the present invention. This embodiment is directed to an antenna device structured such that antenna elements 1501, 1502 and 1503 are received in a recess 1505 defined in the conductive base plate 1504. This structure eliminates a projection of the antenna device from a car body such as an automobile, and also the interaction of the peripheral end portion of the antenna element 1510 with the conductive base plate 1504 enables to improve the directional gain performance.

FIGS. 16(a) and 16(b) are schematic structural diagrams showing other examples of an antenna device according to this embodiment. In the antenna device shown in FIG. 16(a), an antenna 1610 made up of antenna elements 1601, 1602 and 1603 and an antenna 1620 made up of antenna elements 1606, 1607 and 1608 are disposed on the same plane and also received in a recess 1605 defined in a conductive base plate 1604. In this example, the antenna 1610 and the antenna 1620 are made up of antennas different in size and shape, but they may be identical in size and shape. The antennas are disposed so that the respective feeder sections are close to the antennas. Also, FIG. 16(b) is a diagram showing an example in which the same antenna is disposed close to a planer conductive base plate 1609.

FIGS. 17(a) and 17(b) are schematic structural diagrams showing still other examples of an antenna device according to this embodiment. In the antenna device shown in FIG. 17(a), an upper antenna 1710 and a lower antenna 1720 which are made up of antenna elements 1701, 1702 and 1703 are disposed upper and lower, and also received in a recess 1705 defined in a conductive base plate 1704. In this example, the antenna 1710 and the antenna 1720 are structurally identical in size and shape, but they may be different in size and shape. Also, FIG. 17(b) is a diagram showing an example in which the same antenna is disposed close to a planer conductive base plate 1706. In the case where the respective antenna elements are identical in size with each other in this way, all of the tuning frequencies are identical with each other. Therefore, the frequency band width of the entire antenna device is identical with that in case of a single element, but as shown in FIG. 41, because the gains of the respective antenna elements are accumulated in comparison with a case in which the antenna element is single, the gain of the entire antenna device is heightened, thereby being capable of realizing a high-gain and high-selective antenna.

FIGS. 18(a) and 18(b) are schematic structural diagrams showing still other examples of an antenna device according to this embodiment. In the antenna device shown in FIG. 18(a), three antennas 1801, 1802 and 1803 made up of a plurality of dipole antenna elements each having a bent portion are formed using a multi-layer printed board 1806, and then received in a recess 1805 defined in a conductive base plate 1804. In this example, those three antennas 1801, 1802 and 1803 are structurally identical in size and shape, but they may be different in size and shape. Also, three antennas are provided in this example, but four or more antennas may be formed into layers. FIG. 18(b) is a diagram showing an example in which the same antenna is disposed close to a planer conductive base plate 1807. In this way, with the structure in which a plurality of antennas are laminated using a multi-layer printed board, an antenna high in gain and high in selectivity can be readily obtained.

(Embodiment 7)

FIGS. 19(a) and 19(b) are schematic structural diagrams showing two examples of an antenna according to a seventh embodiment of the present invention. The antenna according to this embodiment is structured such that two linear conductors each having four bent portions are provided for a feeder section. That is, FIG. 19(a) shows the same antenna device as that shown in FIG. 3(b) as described above, which includes two linear conductors 1902 and 1903 whose curving directions at the bent portions are reverse to each other with respect to a feeder point 1901, and FIG. 19(b) shows the antenna device that includes two linear conductors 1904 and 1905 whose curving directions at the bent portions are identical with respect to the feeder point 1901. These configurations enable the antenna to be downsized on a plane and additionally enables to realize the non-directivity.

On the other hand, FIG. 20(a) shows an antenna device having an antenna element 2002 designed such that a length of from a feeder section 2001 to a first bent point P is relatively longer than a length of from the first bent point P to a second bent point Q. Also, FIG. 20(b) shows an antenna device having an antenna element 2002 designed such that a length of from a feeder section 2001 to a first bent point P is relatively shorter than a length of from the first bent point P to a second bent point Q. The above structures enable the antenna device to be equipped in a slender location.

In this embodiment, two linear conductors are provided for the feeder section, but the present invention is not limited by or to this structure, and may be applied to one linear conductor. Likewise, the number of bent portions is not limited by or to those embodiments.

Also, in this embodiment, the linear conductors are

bent. Instead, they may be curved or spirally shaped. For example, as shown in FIG. 21(a), the antenna device may be structured to include two linear conductors 2102 and 2103 whose curving directions at the curved portions are reverse with respect to the feeder section 2101, or structured to include two linear conductors 2104 and 2105 whose curved directions at the curved portions are identical with respect to the feeder section 2101. Also, as shown in FIG. 21(b), the antenna device may be structured to include two spiral linear conductors 2106 and 2107 whose winding directions are reverse with respect to the feeder section 2101, or structured to include two spiral linear conductors 2108 and 2109 whose winding directions are identical with respect to the feeder section 2101.

Also, in the case of producing the antenna according to this embodiment, the antenna element may be formed by machining a metal member, or may be formed on a substrate by using a printed wiring. The use of the printed wiring extremely simplifies the production of the antenna, thereby being capable of expecting a reduction of the costs, downsizing and an improvement in reliability.

The antennas of this embodiment can be likewise applied to the following embodiments.

(Embodiment 8)

FIGS. 22(a) and 22(b) are schematic structural diagrams showing examples of an antenna device according to an eighth embodiment of the present invention. The antenna device according to this embodiment is structured such that an antenna element is disposed close to the conductive base plate, and an earth terminal of the antenna is connected to the base plate. For example, as shown in FIG. 22(a), an antenna element 2201 is disposed close to a base plate 2204, and its earth terminal 2203 is connected to the base plate 2204. Although this antenna device is similar to the structure of FIG. 4(b), they are different in that a feeding terminal 2202 is disposed at a position where the feeding terminal 2202 penetrates the conductive base plate 2204. The above structure enables to obtain desired impedance characteristic and directivity.

Also, FIG. 22(b) is structured to provide a switching element between an earth terminal of the antenna and the conductive base plate. As shown in the figure, a switching element 2205 is disposed between the earth terminal 2203 of the antenna element 2201 and the conductive base plate 2204, and a state in which optimum radio wave propagation is obtained is selected by connecting or disconnecting the earth terminal 2203 and the conductive base plate 2204. In this case, the switching element 2205 is structured so as to be remotely controlled so that control is made in response to a radio wave receiving state. In this example, in the case where the earth terminal 2203 is connected to the conductive base plate 2204, the antenna forms a vertical polarization antenna, but in the case where the earth terminal 2203 is not connected to the conductive base plate 2204, it forms a horizontal polarization antenna.

Also, in the above FIG. 22(b), the feeder terminal 2202 penetrates the conductive base plate 2204, but the present invention is not limited by or to this example. For example, as shown in FIG. 23, the feeding terminal 2302 and the earth terminal 2303 may not penetrate the conductive base plate 2304.

FIGS. 24(a) and 24(b) show positional relation between a conductive base plate and an antenna according to this embodiment. As shown in FIG. 24(a), a conductive base plate 2402 plane and an antenna 2401 plane are so disposed as to be in parallel with each other at a distance h. In this case, the directivity of the antenna 2401 can be changed to a desired direction by controlling the distance h. Also, in the case where the antenna 2401 and the conductive base plate 2402 approach each other, the tuning frequency is heightened, whereas in the case where they are away from each other, the tuning frequency is lowered. Therefore, it may be structured such that the distance h is controlled according to the radio wave receiving state. For example, the control of the distance h may be made by moving the antenna 2401 perpendicularly with respect to the antenna plane by using a feed mechanism, a slide mechanism not shown or the like. Alternatively, an insulating spacer not shown is interposed between the antenna 2401 and the conductive base plate 2402, and the spacer is moved in parallel with the antenna plane, to thereby adjust the mount of inserting the spacer. In this example, in order to obtain a desired antenna performance at the time of producing the antenna, the size of the spacer may be decided. The spacer between the base plate and the antenna can be made of a material low in dielectric factor such as foam styrene.

Also, as shown in FIG. 24(b), the conductive base plate 2402 and the antenna 2403 may be disposed three-dimensionally such that a predetermined angle θ (in this example $\theta = 90°$) is defined between the conductive base plate 2402 plane and the antenna 2403 plane. The predetermined angle θ may be adjusted by a hinge mechanism or the like, thereby enabling the control of directivity of the antenna 2403.

Further, in this embodiment, one antenna element is used. However, the present invention is not limited by or to this but may use two or more antenna elements. Also, the base plate is formed of a single conductor, but a body of an automobile, etc., is available as the base plate.

(Embodiment 9)

FIGS. 25(a) and 25(b) are schematic diagrams showing examples of an antenna device according to a ninth embodiment of the present invention, in which a plurality of antenna elements are disposed within a predetermined area, and one antenna is structured by an

antenna group with a single feeder. As shown in FIG. 25(a), a plurality of antenna elements 2501, 2502 and 2503 are modified in a single feeder, and one antenna is structured by an antenna element group. For example, each of plural elements covers a different frequency, thereby being capable of realizing an antenna wide in frequency band which covers a desired frequency band as a whole. In particular, in the arrangement shown in FIG. 25(a), since the element length of the outer antenna 2501 is naturally longer than the element length of the inner antenna 2503, it is easy to set the antenna 2501 longer in element length to a relatively low tuning frequency, and the antenna 2503 shorter in element length to a relatively high tuning frequency, thereby being capable of structuring an antenna that covers a wide frequency band as a whole.

Also, as shown in FIG. 25(b), the antenna device may be structured in such a manner that a plurality of antenna elements are provided on the same plane, but they do not come into each other.

Also, in the case where frequency bands covered by each of plural antenna elements are identical with each other, the antenna efficiency can be enhanced.

Further, in order to obtain isolation between the individual antenna elements, distances between the respective antenna elements may be defined by intervals necessary to obtain predetermined isolation. Alternatively, an isolator or reflector may be connected to the individual antenna elements.

In this embodiment, the number of antenna elements is 2 or 3. However, the present invention is not limited by or to this as long as the number of antenna elements is two or more.

(Embodiment 10)

FIGS. 26(a) and 26(b) are schematic diagrams showing examples of an antenna device according to a tenth embodiment of the present invention. A difference of this embodiment from the above ninth embodiment resides in that as shown in FIG. 26(a), antenna elements 2601, 2602 and 2063, or 2604, 2605 and 2606 are so arranged to be laminated in a direction perpendicular to a reference plane. An arrangement state of the antenna elements on the plane of projection is that all of the antenna elements may be superimposed on each other as shown in the left drawing, the antenna elements may be partially overlapped with each other as shown in the right drawing, or they may be separated from each other. FIG. 26(b) shows an applied example of this embodiment, that is, a partially cut view showing antennas 2611 and 2612 formed on a multi-layer printed board 2609 using a printed wiring in a state where the arrangement of the antennas on the horizontal plane are partially overlapped. The coupling of both the elements at a predetermined position is enabled by making a conductor pass through a through-hole 2610.

(Embodiment 11)

FIGS. 27(a) and 27(b) are schematic diagrams showing examples of an antenna device according to an eleventh embodiment of the present invention, and FIG. 27(a) shows an example of a feeder section of an antenna in which a plurality of antenna element groups are modified in a single feeder. As shown in FIG. 27(a), taps 2704, 2705 and 2706 are formed at predetermined positions of the respective antenna elements 2701, 2702 and 2703, and then connected to a feeding terminal 2707. In this example, the directions of those taps are identical between all of the antenna elements, but may be set arbitrarily for each of the antenna elements.

FIG. 27(b) shows an antenna in which electrodes extending from a feeding terminal to the tap positions of the respective antenna elements are made common. As shown in the figure, taps 2704, 2705 and 2706 are formed at predetermined positions of the respective antenna elements 2701, 2702 and 2703, and an electrode 2708 extending from the tap positions to the feeding terminal 2707 is commonly used. With this structure, not only the structure is simplified but also the space can be saved by disposing the electrode 2708, for example, in parallel with the outermost antenna element 2701.

Also, FIGS. 28(a) and 28(b) show antennas providing the taps of the respective antenna elements through reactance elements. As shown in FIG. 28(a), the respective antenna elements 2801, 2802 and 2803 may be connected to a feeding terminal 2807 through reactance elements 2804, 2805 and 2806, respectively, or as shown in FIG. 28(b), a reactance element 2809 may be disposed in a common electrode 2808 between the feeding terminal 2807 and the tap positions. In this example, as shown in FIGS. 9(a) and 9(b), a reactance element may be disposed between the feeding terminal and the earth terminal. In this way, the use of an appropriate reactance element enables to obtain a desired impedance, frequency band and maximum efficiency. A variable reactance element may be used while being adjusted as the reactance element.

(Embodiment 12)

FIG. 29 is a schematic diagram showing an example of an antenna device according to a twelfth embodiment of the present invention, in which a plurality of antenna elements are disposed within a predetermined area which is in the vicinity of a conductive base plate, one antenna is structured by an antenna group with a single feeder, and an earth terminal of its feeding section is connected to the conductive base plate. As shown in FIG. 29, a plurality of antenna elements 2901, 2902 and 2903 are modified in a single feeder by a feeding terminal 2907 disposed to penetrate a conductive base plate 2909, one antenna is structured by an antenna group, and an earth terminal 2908 of the feeder

section is connected to the conductive base plate 2909. The above structure enables a downsized and high-gain antenna to be equipped on the plane in the vicinity of the conductive base plate.

(Embodiment 13)

FIGS. 30(a) to 30(c) are schematic diagrams showing examples of an antenna device according to a thirteenth embodiment of the present invention.

As shown in FIG. 30(a), an interval between opposed portions 3001 and 3002 of an antenna element at an open terminal side thereof is set to a predetermined distance, and coupling of those portions is controlled to control a tuning frequency.

Also, setting of the coupling of those opposed portions 3001 and 3002 of the antenna element at the open terminal side thereof may be made by providing a dielectric 3003 as shown in FIG. 30(b), or may be connected to each other through a reactance element 3004 as shown in FIG. 30(c). In this example, the coupling may be controlled by the dielectric 3003 being structured to be movable, or the coupling may be controlled by a variable reactance as the reactance element 3004.

Also, in this embodiment, the number of antenna elements is one, but as shown in FIGS. 25(a) and 25(b), the number of antenna elements may be two or more. Thus, the present invention is not limited by or to this example.

(Embodiment 14)

FIGS. 31(a) to 31(c) are schematic diagrams showing examples of an antenna device according to a fourteenth embodiment of the present invention.

As shown in FIG. 31(a), distances between open terminal sides 3101 and 3102 of the antenna element and a neutral point 3103 or opposed portions 3111, 3112 in the vicinity of the neutral point 3103 is set to a predetermined distance, to thereby control a tuning frequency.

Also, the setting of the coupling the open terminal sides of the antenna element with the neutral point 3103 or the opposed portions in the vicinity of the neutral point may be made by providing a dielectric 3104 as shown in FIGS. 31(b) and 31(c), or may be connected to each other through a reactance element 3105 or 3106 as shown in FIGS. 31(b) and 31(c). In this example, like the above thirteenth embodiment, the coupling may be controlled with the dielectric element 3104 being structurally movable, or the coupling may be controlled with variable reactance as the reactance elements 3101 and 3102.

Similarly, in this embodiment, the number of antenna elements is one, but as in the antennas shown in FIGS. 25(a) and 25(b), the number of antenna elements may be two or more. Thus, the present invention is not limited by or to this example.

(Embodiment 15)

FIGS. 32(a) and 32(b) are schematic diagrams showing examples of an antenna device according to a fifteenth embodiment of the present invention. In the antenna devices according to this embodiment, at least one linear conductor is connected to both poles of a coil, respectively, an earth terminal is extended from a neutral point of the coil, a tap is formed at the respective linear conductors or predetermined position of the coil, and a feeding terminal is led out from the tap. As shown in FIG. 32(a), a coil 3203 has linear conductors 3201 and 3202 on both ends thereof, respectively. An earth terminal 3206 is extended from a neutral point of the coil 3203, and a tap 3204 is formed at a predetermined position of the linear conductor (in this example, 3202) so that a feeding terminal 3205 is led out from the tap. Alternatively, as shown in FIG. 32(b), a tap 3204 may be formed at a predetermined position of the coil 3203 to lead out the feeding terminal 3205.

The above structure enables the tuning frequency of the antenna to be adjusted by the number of winding of the coil, and also enables the downsizing and a wide frequency band to be realized.

FIGS. 33(a) and 33(b) show cases in which a coil has a plurality of linear conductors. As shown in FIG. 33(a), a coil 3307 has a plurality of linear conductors 3301, 3302 and 3303 and 3304, 3305 and 3306 on both ends thereof, respectively. An earth terminal 3311 is extended from a neutral point 3310 of the coil 3307, and a tap 3308 is formed at a predetermined position of the linear conductor (in this example, 3304, 3305 and 3306) so that a feeding terminal 3309 is led out from the tap. Alternatively, as shown in FIG. 33(b), a tap 3312 may be formed at a predetermined position of the coil 3307 to lead out the feeding terminal 3309. In this example, the number of one-sided linear conductors is three, but the present invention is not limited by or to this and the number of linear conductors may be two or more.

Also, in this embodiment, the shape of the linear conductor that forms an antenna element is straight, but it may have at least one bent or curved portion or be spirally shaped. The present invention is not limited by or to this.

(Embodiment 16)

FIG. 34 is a schematic diagram showing an example of an antenna device according to a sixteenth embodiment of the present invention. The antenna device according to this embodiment is structured to include one or two groups each consisting of a plurality of linear conductors through coils for a feeder section. As shown in FIG. 34, electrodes 3407 and 3408 each resulting from grouping a plurality of linear conductors 3401, 3402, 3403 and 3404, 3405, 3406 are connected to a feeder section 3411 through coils 3409 and 3410. The above structure enables the tuning frequency of the

antenna to be adjusted by the number of winding of the coils and also enables the downsizing and a wide frequency band to be realized.

(Embodiment 17)

FIG. 35 is a schematic diagram showing an example of an antenna device according to a seventeenth embodiment of the present invention. In the antenna device according to this embodiment, a plurality of antennas made up of a plurality of antenna element groups are located in a predetermined area, to conduct diversity reception where an antenna which is optimum to a receiving state is selected from those antennas. For example, in FIG. 35, one antenna by which optimum radio wave propagation is obtained is selected from two antennas 3501 and 3502 by a diversity change-over switch 3503 connected to a feeder section. In this example, the number of antennas is not limited to two as in this embodiment, but may be three or more. Also, the kind of antenna is not limited to the antenna with the shape shown in FIG. 35 but other kinds of antennas described in the above-described embodiments or the combination of different kinds of antennas may be applied.

Also, in the control for selecting an optimum antenna from a plurality of antennas, control for selecting an antenna maximum in a receiver input may be conducted. Alternatively, control for selecting an antenna minimum in a multi-pass interference level may be conducted.

Further, a balanced-to-unbalanced transformer, a mode transformer or an impedance transformer may be connected to the respective antenna element feeder sections or the feeder section of the antenna obtained by converting a plurality of antenna element groups in a single feeder according to the above embodiments 1 to 17.

(Embodiment 18)

FIG. 36 is a perspective view for explanation of an example of a location where an antenna device is equipped according to an eighteenth embodiment of the present invention. In this embodiment, there is described an equipment location where an automobile is equipped with an antenna. The equipped antenna is an antenna device described in the above respective embodiments. The equipment location of the antenna is, as shown in FIG. 36, a rear spoiler 3601, a trunk lid rear panel 3602, a rear tray 3603, a roof spoiler 3604, a roof box 3606 or a roof 3605 such as a sun roof visor.

Also, in the case where the antenna is intended to be equipped vertically, for example, as shown in FIG. 37(a), the antenna may be equipped on both end portions 3703 of spoilers 3701 and 3702, an end portion 3703 of a sun visor, etc., of an automobile, or as shown in FIG. 37(b), it may be equipped on a pillar portion 3704. It is needless to say that the present invention is not limited to these examples, and the antenna can be equipped on other portions of the automobile if they are inclined to some degree with respect to a horizontal plane. The equipment of the antenna on those positions enables the antenna to be liable to receive desired polarization.

As described above, in the respective antenna devices according to the present invention, since the antenna plane and the car body plane which is a conductive base plate can be disposed close to each other in parallel, the antenna can be equipped without being projected from the car body, and also since an area occupied by the antenna is small, the antenna can be equipped in a small space. Therefore, the beauty of the appearance is improved, the occurrence of a wind sound can be suppressed, and further problems such as a risk that the antenna is robbed, the removal of the antenna when washing the automobile, and so on can be eliminated.

(Embodiment 19)

FIG. 38 is a schematic diagram showing an example of a mobile communication apparatus having an antenna device according to a nineteenth embodiment of the present invention. As shown in FIG. 38, an antenna 3801 which is any one of the antennas described in the above embodiments is equipped on the ceiling portion of a car body 3805 of an automobile or the like. In this example, if the antenna 3801 is received in a recess 3806 formed in the ceiling portion, there is no case in which the antenna is projected from the outline of the car body 3805. The antenna 3801 is connected to a communication unit 3804 made up of an amplifier 3802, a modulator/demodulator 3803 and so on mounted inside of the car body 3805.

(Embodiment 20)

FIGS. 39(a) and 39(b) are schematic diagrams showing examples of a portable telephone having an antenna device according to a twentieth embodiment of the present invention. FIG. 39(a) shows an example in which a conductive shield case 3902 disposed inside of a resin case 3901 of the portable telephone is utilized as a conductive base plate, and an antenna 3903 is disposed on an inner side surface of the case 3901 so as to be in parallel with the shield case 3902. Also, FIG. 39(b) shows an example in which an antenna 3904 is disposed on an outer top portion of the resin case 3901 of the portable telephone, and a conductive base plate 3905 is disposed on an inner portion opposite to the antenna 3904 across the case 3901. In this example, the top portion of the shield case 3902 is not employed as the conductive base plate because normally there is a small area. In both of FIGS. 39(a) and 39(b), the antenna to be used may be, in particular, an antenna

the number of bent portions of which or the number of windings is large because such an antenna can be readily downsized among the antennas described in the above respective embodiments.

The use of the above structure enables electromagnetic wave interference on a human body to be reduced without lowering the antenna efficiency if the conductive base plate is at the side of the human body because the directional gain of the conductive base plate side is extremely smaller than that of the antenna side.

In the above eighteenth embodiment, there is described the example in which the antenna device is equipped on the automobile. However, the present invention is not limited to this example, and may be applied to other movable bodies such as an aircraft or ship. Alternatively, the antenna device is not limited to the movable bodies but may be equipped on a road surface, a shoulder, a fare gate, within a tunnel of a traffic road such as a superhighway, and also a wall surface and window of a building, etc.

Also, in the above nineteenth embodiment, the antenna device for the movable communication unit is described as an example. However, the present invention is not limited to this embodiment. For example, the present invention is available to a device that receives or transmits a radio wave such as a television, a radio cassette and a radio unit.

Further, in the above twentieth embodiment, the portable telephone is described as an example. However, the present invention is not limited to this. For example, the present invention is also applicable to other portable radio unit such as PHS, a pocket bell or a navigation system.

(Embodiment 21)

FIGS. 42(a) and 42(b) are schematic structural diagrams showing an antenna device according to a twenty-first embodiment of the present invention. That is, FIG. 42(a) shows an antenna device that is a monopole wide frequency band antenna, which is made up of a main antenna element 4202 one end of which is connected to a ground 4204, an antenna element 4201 disposed close to the main antenna element 4202, longer in element length than the antenna element 4202 and having both ends not grounded, and an antenna element 4203 shorter in element length than the antenna element 4202 and having both ends not grounded. The main antenna element 4202 has a tap which is connected to a feeder point 4206 through an impedance adjustment reactance element 4205. Also, FIG. 42(b) shows an example in which the antenna elements 4201, 4202 and 4203 of the antenna device shown in FIG. 42(a) are formed on the printed board 4207 by using a printed wiring.

FIGS. 43(a) and 43(b) show examples in which the antenna device of the above embodiment is of the dipole type. That is, FIG. 43(a) shows an antenna device that is a dipole wide-frequency band antenna, which is made up of a main antenna element 4302 a center portion of which is connected to a ground 4304, an antenna element 4301 disposed close to the main antenna element 4302, longer in element length than the antenna element 4302 and not grounded anywhere, and an antenna element 4303 shorter in element length than the antenna element 4302 and not grounded anywhere. The main antenna element 4302 has a tap which is connected to a feeder point 4306 through an impedance adjustment reactance element 4305. Also, FIG. 43(b) shows an example in which the antenna elements 4301, 4302 and 4303 of the antenna device shown in FIG. 43(a) are formed on the printed board 4307 by using a printed wiring.

The above structure makes the frequency band wide, the gain high and the adjustment easy with a simple structure.

In the above embodiment, the antenna element shorter than the main antenna element and the antenna element longer than the main antenna element which are disposed close to the main antenna element are formed by one piece, respectively. However, the present invention is not limited by this example, and two or more shorter antenna elements and longer antenna elements may be provided, respectively.

(Embodiment 22)

FIGS. 44(a) and 44(b) are schematic structural diagrams showing antenna devices according to a twenty-second embodiment of the present invention. That is, FIG. 44(a) is similar to the antenna device in which the conductive base plate is disposed close to the antenna element as described, for example, in FIG. 10(a) and 10(b), but the antenna device of FIG. 44(a) is different from such antenna device in that the size of the conductive base plate 4404 disposed close to the antenna elements 4401, 4402 and 4403 is set to be substantially equal to or smaller than that of the outermost antenna element 4401. This structure improves the horizontal polarization gain in comparison with a case in which the conductive base plate is larger than the antenna element.

Also, FIG. 44(b) shows an example in which the antenna device shown above in FIG. 44(a) is received in a recess formed in, for example, a movable body, a communication unit case, a house wall, other device cases, etc., in which the antenna earth (conductive base plate) 4404 is not connected to the case earth. This structure enables a high gain to be obtained in both of the horizontal and vertical polarizations. The FIG. 94 shows a directional gain performance of the antenna for the vertical polarization wave. The distance between the antenna earth and case earth(namely separate distance) are (a)10mm,(b)30mm,(c)80mm,(d)150mm respectively and they shows that the gain becomes higher according to the distance becomes smaller. That

is the capability becomes improved as the antenna earth and the case earth comes nearer. Further in this example in order to prevent a protrusion of the antenna from the outside case, the antenna earth 4404 is installed within a concave part which is formed at such cases of movile body, transmission case, house wall, and soon. But the capability of the antenna is same even when the antenna element is provided to with suitable short distance the plane surface of a case earth. Such embodiment is included in the claimed present invention.

Now in the above embodiment balance type is used as the antenna element but unbalance type antenna element can be used.

(Embodiment 23)

FIGS. 45(a) and 45(b) are schematic structural diagrams showing examples of an antenna device according to a twenty-third embodiment of the present invention. This embodiment shows an example of how close the conductive base plate should be disposed to the antenna element, and FIG. 45(a) shows an example in which there is provided one antenna element. That is, a distance h between the antenna element 4501 (accurately, an antenna earth connection portion) and a conductive base plate 4502 is set within the limit of 0.01 to 0.25 times (that is, 0.01λ to 0.25λ) as large as the wavelength λ in the resonance frequency f of the antenna. This structure makes the gain high and the adjustment easy.

Also, FIG. 45(b) shows a case in which four antenna elements are provided, and antenna elements 4503, 4504, 4505 and 4506 are disposed at different distances from a conductive base plate 4507, respectively. As shown in FIG. 45(b), in the case where the element length is different among the respective antenna elements, as the element length is shortened, the resonance frequency of the antenna element is heightened more, and the wavelength is shortened. Accordingly, a distance h1 of the antenna element 4506 shortest in element length is set to be the smallest, a distance h2 of the antenna element 4503 longest in element length is set to be the largest, and a distance of the intermediate antenna elements 4504 and 4505 may be set according to the wavelength in the resonance frequency of the respective antenna elements. In this case, the respective distances between the respective antenna elements 4503, 4504, 4505, 4506 and the conductive base plate 4507 are set so as to satisfy the conditions of 0.01 to 0.25 times (that is, 0.01λ to 0.25λ) with respect to the respective wavelengths in the resonance frequency of the respective antenna elements as described above.

(Embodiment 24)

FIG. 46 is a schematic structural diagram showing an example of an antenna device according to a twenty-fourth embodiment of the present invention. In this embodiment, a high dielectric material is provided between an antenna element 4601 and a conductive base plate 4602. Therefore, this embodiment is applicable to the structure of the embodiments in which the conductive base plate is disposed close to the antenna element among the above-described antenna devices. In this example, the provision of the high dielectric material between the antenna element and the conductive base plate enables a distance between the antenna element and the conductive base plate to be equivalently reduced.

(Embodiment 25)

FIG. 47 is a perspective view showing an example in which an antenna device is applied to a car body according to a twenty-fifth embodiment of the present invention. That is, any antenna devices of the above-described embodiments according to the present invention are located at four positions of a car body pillar portion 4701 at the front, rear, right and left sides of an automobile and at one position of a roof portion, that is, at five positions in total, to thereby provide a diversity structure by those plane antennas. This structure enables excellent transmission and reception with respect to both of the horizontal and vertical polarizations. In this example, there are five positions at which the antennas are located, but the locations are not limited by this.

(Embodiment 26)

FIG. 48 is a perspective view showing an example in which locations where an antenna device is equipped are applied to the respective parts of a car body according to a twenty-sixth embodiment of the present invention. That is, any antenna devices of the above-described embodiments according to the present invention are fitted to any location or a plurality of locations which are on the surface of a car body 4801 where the antenna device can be located, such as a roof panel, a bonnet, a body pillar portion, a body side, a bumper, a tire wheel or a floor of the car body 4801 of an automobile. In FIG. 48, an antenna 4802 is equipped on a location where the antenna plane is substantially horizontal, an antenna 4803 is equipped at a location where the antenna plane is obliquely inclined, and an antenna 4804 is equipped at a location where the antenna plane is substantially vertical. The figure shows appropriate locations where the antenna should be equipped, and it is unnecessary to equip the antenna on all the locations. Also, it is needless to say that the antenna may be disposed at locations other than those shown in the figure. Also, the kind of the automobile is not limited by a motor car as shown, but an automobile such as a bus or a motortruck is also acceptable.

An antenna 4805 is located such that the antenna plane is horizontal, and in particular, located on a rear

side (under side) of the floor, and the directional characteristic is directed to a road surface. Therefore, the antenna 4805 is suitable for communication with a radio wave source located on (or buried under) a road used for communication, detection of a location where the car body is situated, etc.

As usual, a radio wave used for a TV or FM broadcasting is a radio wave that mainly includes a horizontal polarization, and a radio wave used for a portable telephone, a radio communication unit, etc., is a radio wave that mainly includes a vertical polarization. It is determined whether it is suitable for the horizontal polarization or the vertical polarization according to a direction of locating the antenna. As shown in FIG. 49(a), in an unbalanced three-element antenna 4902 disposed in parallel with a face of a vertical conductive base plate 4901 which is a part of the car body 4801 so that an earth terminal thereof is connected to the conductive base plate 4901, since an electric field is horizontal as shown in the right figure, and the sensitivity can be enhanced with respect to the horizontal polarization, it is effective as a horizontal polarization antenna. This can be realized by equipping the antenna 4804 of FIG. 48 on the locations indicated by the antenna 4804. Also, because the antenna 4802 is an antenna disposed in parallel with a horizontal face of the car body 4801, its electric field is vertical so that the sensitivity becomes high with respect to the vertical polarization. Therefore, it is effective as the vertical polarization antenna. Further, an antenna 4803 is located so as to be obliquely inclined, has a balanced sensitivity between the horizontal polarization and the vertical polarization according to the inclined degree, and can be used, hardly depending on the polarization direction. FIG. 49(b) shows an example of a balanced antenna which is effective as the horizontal polarization antenna as in the above description.

(Embodiment 27)

FIGS. 50(a) to 50(c) are schematic diagrams showing the structures of an antenna device according to a twenty-seventh embodiment of the present invention. A difference of the antenna device according to this embodiment from the above-described antenna devices resides in that a direction of transmitting and receiving a radio wave is not at the antenna element side but at the conductive base plate side. As shown in FIG. 50(a), a three-element antenna 5002 is disposed in parallel with a conductive base plate 5001 at a given interval, an earth end portion of the antenna 5002 is connected to the conductive base plate 5001, and the conductive base plate 5001 side is directed outward. In FIG. 50(b), this antenna exhibits a symmetric directional characteristic with respect to an upper side of the conductive base plate 5001 region (side opposite to the antenna 5002) that corresponds to a region covered with the antenna 5002 surface and a lower side thereof with respect to the antenna 5002. For that reason, even if a direction of arranging the antenna 5002 and the conductive base plate 5001 is reverse to that of the conventional arrangement, the same effects as those of the antennas as described in the above embodiments can be obtained. Further, as shown in FIG. 50(c), even if the conductive base plate 5003 is shaped in a closed case, the same characteristic is obtained, and even if electricity is fed to the antenna 5002 inside of the conductive base plate 5003, communication is enabled to the exterior through the conductive base plate 5003.

FIG. 51 shows an example in which the unbalanced antenna device of FIG. 50 is changed to a balanced antenna device with the same effects as those described above.

Also, FIG. 52 shows an example in which an antenna device of this embodiment is applied to the respective locations of a car body as shown in FIG. 48. In FIG. 52, like FIG. 48, an antenna 5202 is equipped on a location where the antenna plane is substantially horizontal, an antenna 5203 is equipped at a location where the antenna plane is obliquely inclined, and an antenna 5204 is equipped at a location where the antenna plane is substantially vertical. Also, the antenna 5205 is located so that the antenna plane is horizontal, and in particular located inside of a floor, which is suitable for communication with a radio wave source located on a road as in the case of FIG. 48. Although all of those antennas are disposed inside of the car body 5201, the same performance as that in the case where they are located on the body surface can be realized for the above reason, and since the antennas are not exposed to the exterior of the car body, it is greatly advantageous from the viewpoints of the beauty, damage, theft, etc. Further, as shown in FIG. 52, the antenna device can be equipped even on locations to which the antenna cannot be normally fitted, such as a back mirror, a room sun visor or a number plate by using its interior.

FIG. 53 is a perspective view showing an example in which an antenna device is applied to a portable telephone according to this embodiment, in which an antenna 5302 is located inside of an earth exterior case 5301 made of a conductor, and the antenna earth is connected to the earth exterior case 5301. With this structure, the antenna can be used as in the case where the antenna is located outside of the earth exterior case 5301, and the antenna is not exposed to the exterior, thereby leading to an advantage in handling. In this example, the portable telephone is described as an example, but the present invention is also applicable to TV, PHS, other radio units, etc.

FIG. 54 is a perspective view showing an example in which an antenna device is applied to a general house according to this embodiment. That is, an antenna 5402 is located inside of a conductive door of a house 5401, an antenna 5403 is located inside of a conductive window (for example, a shutter), an antenna

5404 is located inside of a conductive wall, and an antenna 5405 is located inside of a conductive roof. In this way, if the antenna is located using the inside of a construction which is a conductor of a house 5401, since the antenna is not exposed to the exterior, a damage or deterioration by wind and rains can be prevented, leading to a long lifetime.

Even in the case where the house is a construction which is not a conductor, the antenna can be readily equipped if a conductor is fitted to the outside of only a location where the antenna is equipped.

(Embodiment 28)

FIGS. 55(a) and 55(b) are schematic diagrams showing the structure of an antenna device according to a twenty-eighth embodiment of the present invention. This embodiment is structured in such a manner that a conductive base plate 5501 and an antenna 5502 located close to the conductive base plate 5501 in parallel can be rotated about an axis indicated by a dashed line as a center at the same time. As shown in FIG. 55(a), because an electric field is horizontal as shown in the right drawing in a state where the antenna 5502 is vertical, the sensitivity becomes high with respect to the horizontal polarization. On the other hand, as shown in FIG. 55(b), because an electric field is vertical as shown in the right drawing in a state where the antenna 5502 is horizontal, the sensitivity becomes high with respect to the vertical polarization. The antenna can be adjusted to an optimum direction according to the polarization state. It is needless to say that it may be set to a state where the antenna is obliquely inclined. FIG. 95 shows the directional gain performance of the conditions of FIG. 55(a) and the FIG. 96 shows the directional gain performance of the conditions of FIG.55(b). As apparent from these FIGs. 95,96, the antenna has high sensitivity against a horizontal polarization wave when the antenna is provided vertically and the antenna has high sensitivity against a vertical polarization wave when the antenna is provided horizontally.

In this example, as a method of rotating the conductive base plate 5501 and the antenna 5502, there are a manual type in which a handle may be rotated by hands, and an automatic type using a drive unit such as a motor.

FIG. 56(a) is a schematic diagram showing the structure of an antenna device for realizing the above effect without rotating the antenna. That is, ferroelectrics 5603 are disposed between a conductive base plate 5601 and an antenna 5602 so that an antenna 5602 is sandwiched. With this structure, as shown in the right drawing of FIG. 56(b), because an electric field between the conductive base plate 5604 and the antenna 5605 is expanded horizontally through the ferroelectrics 5606, a vertical component is reduced whereas a horizontal component is increased in comparison with a case where there is no ferroelectrics shown in the left drawing. In this way, the antenna can be set to a vertical polarization mode or a horizontal polarization mode according to the presence/absence of the ferroelectrics. In the case where the antenna is located in a vertical state, the effect is reverse to the above. Two kinds of ferroelectrics 5603 which are mounted and not mounted, respectively, when manufacturing may be prepared. Alternatively, the ferroelectrics may be designed so as to be removably attached by the provision of a removably attachment groove or the like.

(Embodiment 29)

FIGS. 57(a) to 57(c) are diagrams showing examples of the structure of an antenna device according to a twenty-ninth embodiment of the present invention. The antenna devices according to the above-described embodiments use an element bent so as to save a space for location. On the other hand, in this embodiment, there is used a straight linear element or an element shaped along the configuration of a structural member so that the element can be located on a slender structural member fitted on an automobile or the like.

FIG. 57(a) shows an example in which a straight linear antenna 5702 consisting of three elements is disposed close to the surface of a slender plate-like conductive base plate 5701. FIG. 57(b) shows an example in which a straight linear antenna 5704 consisting of three elements is disposed close to the surface of a pipe-shaped conductive base plate 5703 in such a manner that the respective elements are apart from the conductive base plate 5703 at given distances. FIG. 57(c) shows an example in which a straight linear antenna 5706 consisting of three elements is disposed close to the surface of a rectangular cylindrical conductive base plate 5705 in such a manner that the respective elements are apart from the conductive base plate 5705 at given distances.

Also, FIGS. 58(a) to 58(c) are schematic diagrams showing examples in which, in the case where the configuration of the conductive base plate is curved or bent in the examples of FIGS. 57(a) to 57(c), elements are curved or bent along that configuration, and FIG. 58(a) shows an example in which an antenna 5802 consisting of three elements is disposed close to the surface of a curved pipe-shaped conductive base plate 5801, in which the respective elements are curved in the same manner as the curved pipe-shaped conductive base plate 5801 and apart from the conductive base plate 5801 at given distances. FIG. 58(b) shows an example in which an antenna 5804 consisting of three elements is disposed close to the surface of a bent rectangular cylindrical conductive base plate 5803, in which the respective elements are bent in the same manner as the conductive base plate 5803 and apart from the conductive base plate 5803 at given distances. FIG. 58(c) shows an example in which an antenna 5806 consisting

of three elements is disposed close to the surface of a bent plate-like conductive base plate 5805, in which the respective elements are bent in the same manner as the conductive base plate 5805.

Also, FIG. 59(a) shows an example of an antenna 5902 disposed along the periphery of the surface of a cylindrical conductive base plate 5901, and FIG. 59(b) shows an example of an antenna 5904 disposed along the periphery of the surface of a spherical conductive base plate 5903.

In this embodiment, the antenna is located outside of the structural member which is a conductive base plate. However, the present invention is not limited by or to this, but the antenna may be located inside of a plate-shaped member or in the interior of a cylindrical member, etc.

FIGS. 63 and 65 are diagrams showing an applied example of an antenna device according to this embodiment. FIG. 63 shows an example in which an antenna 6302 is located on the surface of a slender roof rail 6303 on the roof of a car body 6301, and FIG. 65 shows an example in which an antenna 6502 is located in the interior of a slender roof rail 6503 on the roof of a car body 6501.

Likewise, FIGS. 64 and 66 are diagrams showing an applied example of an antenna device according to this embodiment. FIG. 64 shows an example in which an antenna 6403 is located on the surface of a slender roof box 6402 on the roof of a car body 6401, and FIG. 66 shows an example in which an antenna 6603 is located in the interior of a slender roof box 6602 on the roof of a car body 6601.

(Embodiment 30)

FIGS. 60(a) and 60(b) are schematic diagrams showing examples of the structure of an antenna device according to a thirtieth embodiment of the present invention. In the antenna device according to this embodiment, in the structure having an antenna 6002 consisting of three elements which are relatively longer in element length and an antenna 6003 consisting of three elements which are relatively shorter in element length with reference to an earth end portion connected to a conductive base plate 6001, feeder points A6005 and B6004 are disposed on those antennas 6002 and 6003, respectively. As shown in FIG. 60(c), the shorter antenna 6003 is tuned to a relatively high-frequency band A whereas the longer antenna 6002 is tuned to a relatively low-frequency band B, thus being capable of realizing an antenna adaptable to two tuning frequency bands by a single antenna. The feeder points A6005 and B6004 may be connected to each other.

FIGS. 61(a) and 61(b) are examples of an unbalanced antenna having two tuning bands. This antenna consists of four elements having one end connected to a conductive base plate 6101 and disposed close to the conductive base plate 6101. A feeder point B6104 is set to an antenna 6102 of two elements relatively longer in element length among those four elements, and a feeder point A6105 is set to an antenna 6103 of two elements relatively shorter in element length. With this arrangement, as shown in FIG. 61(c), the antenna is adaptable to two tuning bands of a high-frequency band A and a low-frequency band B as in the above example. The feeder points A6005 and B6004 may be connected to each other.

FIGS. 62(a) and 62(b) show examples of a balanced antenna having two tuning bands. This antenna consists of four elements whose center points are connected to a conductive base plate 6201 and disposed close to the conductive base plate 6201. A feeder point B6204 is set to an antenna 6202 of two elements relatively longer in element length among those four elements, and a feeder point A6205 is set to an antenna 6203 of two elements relatively shorter in element length. With this arrangement, as shown in FIG. 62(c), the antenna is adaptable to two tuning bands of a high-frequency band A and a low-frequency band B as in the above example. The feeder points A6005 and B6004 may be connected to each other.

As described above, in this embodiment, since there can be provided a high-performance antenna device that suppresses a space where the antenna device is equipped to the minimum, and is adaptable to a plurality of tuning bands, it is also applicable to a small location such as an automobile or a portable telephone.

In this embodiment, two tuning bands are set. However, the present invention is not limited by or to this, for example, may be structured so as to be adaptable to three or more bands. In this case, a plurality of antennas having element lengths corresponding to the respective tuning bands may be provided in such a manner that feeder points are set to the respective antennas.

(Embodiment 31)

FIG. 67 is a schematic diagram shoving an example of an antenna device according to a thirty-first embodiment of the present invention. The antenna device according to this embodiment is structured such that a coil 6703 is provided on the way of a U-shaped antenna element 6701 which is disposed close to a conductive base plate 6702, and one end of the antenna element 6701 is connected to the conductive base plate 6702. Also, a feeder section 6704 is disposed on the way of the antenna element 6701 between the coil 6703 and the conductive base plate 6702. With this structure, a current is concentrated in the coil, and the antenna device can be downsized without any change of the gain. For example, a portion of the antenna element is constituted by a strip line, an area of the antenna is reduced to 1/4. Also, the frequency band width is narrowed to sharpen the frequency band characteristic.

Also, FIG. 68 shows an example in which two antenna elements structured as shown in FIG. 67 are

connected in parallel so as to compose the frequency bands. That is, two antenna elements 6801a and 6801b different in frequency band (length) on the way of which coils 6803a and 6803b are inserted are disposed in parallel, and one end of the respective antenna elements is connected to a conductive base plate 6802. The respective antenna elements 6801a and 6801b are commonly connected to a feeder section 6804 through reactance elements 6805a and 6805b, respectively. With this structure, the bands of two antenna elements can be composed, and in addition to the above effects , the antenna device can be broadened in frequency band.

(Embodiment 32)

FIG. 69 is a schematic diagram showing an example of the structure of an antenna device according to a thirty-second embodiment of the present invention. The antenna device according to this embodiment is structured in such a manner that a coil 6903 is inserted between one end of a U-shaped antenna element 6901 disposed close to a conductive base plate 6902 and the conductive base plate 6902, and the other end of the coil 6903 is grounded to the conductive base plate 6902. Also, a feeder section 6904 is disposed on the way of the antenna element 6901. With this structure, likewise as the above-described thirty-second embodiment, a current is concentrated in the coil, and the antenna device can be downsized without any change of the gain.

FIG. 70 shows an example in which two antenna elements structured as shown in FIG. 69 are connected in parallel so as to compose the frequency bands. That is, two antenna elements 7001a and 7001b different in frequency band (length) are disposed in parallel, and one ends of the respective antenna elements are commonly connected to one end of a coil 7003, and the other end of the coil 7003 is connected to a conductive base plate 7002. The respective antenna elements 7001a and 7001b are commonly connected to a feeder section 7004 through reactance elements 7005a and 7005b, respectively. With this structure, the bands of two antenna elements can be composed, and in addition to the above effects, the antenna device can be broadened in frequency band. Also, since the coil is commonly used for two antenna elements, the structure is simplified with one coil.

(Embodiment 33)

FIG. 71 is a schematic diagram showing an example of the structure of an antenna device according to a thirty-third embodiment of the present invention. A difference of this invention from the above thirty-second embodiment resides in that as shown in FIG. 71, an insulator 7105 is disposed on a conductive base plate 7102, and an antenna element 7101 and a coil 7103 are connected to each other on the insulator 7105. This structure allows the equipment of the coil 7103 to be facilitated, is convenient for the mounting of the coil, and the coil can be stably located. Also, FIG. 72 shows an example of the structure in which frequency bands are composed by two antenna elements 7201a and 7201b. It is complicated to connect the antenna elements and the coil 7203 because the number of antenna elements is increased. However, since a connection point is provided on the insulator 7205 which is disposed on the conductive base plate 7202, the connection between the antenna element and the coil is further facilitated.

(Embodiment 34)

FIG. 73 is a schematic diagram showing an example of the structure of an antenna device according to a thirty-fourth embodiment of the present invention. In the antenna device according to this embodiment, a coil portion is divided into two sections, and antenna elements, the coil and soon are connected using two insulators 7305a and 7305b disposed on a conductive base plate 7302. That is, one end of a U-shaped antenna element 7301 disposed close to the conductive base plate 7302 and one end of a coil 7303a are connected to each other on the insulator 7305a. The other end of the coil 7303a, one end of another coil 7303b and a feeder section 7304 are connected to each other on another insulator 7305b, and the other end of the coil 7303b is grounded to the conductive base plate 7302. Also, FIG. 74 shows an antenna device for composing the frequency bands using two antenna elements 7401a and 7401b, in which an antenna element, a coil and a feeder section are connected as in the structure of FIG. 73.

This structure facilitates the connection of the antenna to another circuit component since the terminal of the feeder section is provided on a circuit substrate.

(Embodiment 35)

FIG. 75 is a schematic diagram showing an example of the structure of an antenna according to a thirty-fifth embodiment of the present invention. The antenna device according to this embodiment is structured such that a zigzag-shaped pattern 7503 is inserted in an antenna element 7501 instead of the coil in the structure of FIG. 67. The structure using the coil is expanded three-dimensional in shape whereas the use of this pattern 7503 enables the pattern to be formed on the same plane as that of the antenna element 7501, and the antenna can be manufactured by a print wiring method or the like. Also, FIG. 76 shows a band composing antenna device using two antenna elements 7601a and 7601b, in which zigzag-shaped patterns 7603a and 7603b are inserted in the respective antenna elements 7601a and 7601b. The pattern may be a saw-tooth like pattern, etc., as shown in FIG. 78(c).

(Embodiment 36)

FIG. 77 is a schematic diagram showing an example of the structure of an antenna according to a thirty-sixth embodiment of the present invention. The antenna device according to this embodiment is structured such that the entire antenna element 7701 disposed close to a conductive base plate 7702 is formed in a zigzag-shaped pattern, and one end of the antenna element 7701 is connected to one end of a coil 7703 the other end of which is grounded. A feeder section 7704 is disposed on the way of the zigzag-shaped antenna element. According to this structure, although the loss is increased, the antenna device can be further downsized to, for example, 1/6 or 1/8. Also, the antenna device may be in the form of a pattern as shown in FIGS. 78(b) and 78(c) except for the above case. FIG. 78(b) shows a three-dimensionally coil shaped one.

(Embodiment 37)

FIG. 79 is a schematic diagram showing an example of the structure of an antenna according to a thirty-seventh embodiment of the present invention. In the antenna device according to this embodiment, an insulator 7904 is disposed on a conductive base plate 7902, a lead wire 7905 drawn out from an antenna element 7901 and a feeder section 7903 are connected to each other on the insulator 7904. This structure facilitates the connection of the feeder section 7903 and other circuit components disposed on the circuit substrate because the feeder section 7903 is provided on the circuit substrate.

Also, FIG. 80 shows the structure in which a through-hole 8005 is defined in a conductive base plate 8002, and an insulator 8004 is disposed on the conductive base plate 8002 opposite to a side where an antenna element 8001 exists. Then, a lead wire 8006 drawn out from the antenna element 8001 penetrates the through-hole 8005 and the insulator 8004 so as to be connected to a feeder section 8003 on the insulator 8004. As a result, since a circuit component is connected to the lead wire on a back side of the conductive base plate 8002, it is convenient to deal with other circuit components which is connected to the feeder section 8003 more than the structure of FIG. 79.

Also, FIG. 81 shows an example where, in the structure of FIG. 80, another conductive plate is provided on the back surface of a conductive base plate (a surface opposite to the antenna element), and a variety of circuit components are mounted on the provided conductive plate. That is, a through-hole 8104 through which a lead wire 8111 drawn out from an antenna element 8101 passes is formed in a conductive base plate 8102 and a conductive plate 8105, and an insulator 8103 is disposed on the conductive plate 8105 side of the through-hole 8104. Further, insulators 8106 of required number are disposed on the surface of the conductive plate 8105 for connection of various circuit components. Then, the lead wire 8111 is connected to the insulator 8103 through the through-hole 8104, and circuit components 8107 to 8110 are connected onto the insulator 8103 and the respective insulators 8106.

This structure enables the circuit to be disposed immediately close to the antenna, and shield between the antenna and the circuit is readily made using the conductive plate, which is effective to downsize the equipment.

Also, FIG. 82 shows an example of the structure in which a circuit component is disposed on the antenna element side. That is, there are provided insulators 8203 of required number for connecting a lead wire 8205 drawn out from an antenna element 8201 onto a conductive base plate 8202, and insulators 8206 of required number for connecting various circuit components. Further, a conductive shield case 8204 is disposed on the conductive base plate 8202 so as to shield the antenna element 8201 from the conductive base plate 8202, and a through-hole 8207 through which the lead wire 8205 passes is formed. Then, the lead wire 8205 is connected onto the insulator 8203 through the through-hole 8207, and circuit components 8208 to 8210 are connected onto the insulator 8203 and the respective insulators 8206. One end of the antenna element 8201 is grounded to the shield case 8204.

According to this structure, although the circuit is received between the antenna element and the conductive base plate, the circuit is shielded by a shield case, and the device can be downsized more than the case of FIG. 81.

(Embodiment 38)

FIG. 83 is a schematic diagram showing an example of the structure of an antenna according to a thirty-eighth embodiment of the present invention. The antenna device according to this embodiment is designed such that an antenna element 8301 is patterned on one surface of an insulating plate 8305, and one end portion 8307 of the antenna element 8301 penetrates an insulating plate 8305. A lead wire 8303 that penetrates the insulating plate 8305 is drawn out from the halfway of the antenna element 8301, a lead wire 8306 patterned on the opposite surface of the insulating plate 8305 in parallel with the antenna element 8305 is connected to the lead wire 8303, and a feeder section 8304 is connected to the lead wire 8306. The feeder section 8304 is disposed at a position close to the one end portion 8307 of the antenna element 8301. Then, the insulating plate 8305 and the conductive base plate 8302 are disposed in parallel with each other, and the one end portion 8307 of the antenna element 8301 is connected to the conductive base plate 8302.

According to this structure, since the ground portion of the antenna element is close to the feeder section, it is convenient for a case where a coaxial cable is con-

nected.

(Embodiment 39)

FIG. 84 is a schematic diagram showing an example of the structure of an antenna according to a thirty-ninth embodiment of the present invention. The antenna device according to this embodiment is designed such that another conductive base plate 8404 is disposed on a large conductive base plate 8402 through an insulating plate 8405, and an antenna element 8401 is disposed close to the conductive base plate 8404. In this example, one end of the antenna element 8401 is grounded to the conductive base plate 8404. Also, it is preferable that the size of the conductive base plate 8404 is made equal to an area of the antenna element 8401. The conductive base plate 8402 is, for example, an automobile, an electric train body, a metallic case portion of a receiver or communication unit, a metallic structural portion of a house, etc. The equipping method may be outside or inside of a car room.

According to this structure, the angle of elevation having an maximum gain becomes nearly horizontal and proper for a communication radio wave (vertical polarization wave) coming laterally.

It is needless to say that the antenna devices according to the above-described thirty-first to thirty-ninth embodiments can be also equipped on the locations described with reference to FIGS. 36, 47, 48, 52, 53, 54, etc.

Also, in the above-described thirty-first to thirty-ninth embodiments, the number of antenna elements is one or two. The present invention is not limited by or to this, and the number of antenna elements may be three or more.

Further, in the above-described thirty-first to thirty-ninth embodiments, the antenna element is U-shaped. The present invention is not limited by or to this, and the antenna may be in other shapes, for example, in the form of a loop.

Still further, the structure providing a connection point using the insulators described in the above-described thirty-seventh to thirty-ninth embodiments is applicable to all of the antenna devices of the above-described other embodiments.

As is apparent from the above description, according to the present invention, an antenna obtained by modifying a plurality of antenna elements including at least one linear conductor having at least one bent or curved portion, or a spiral linear conductor for a feeder section in a single feeder can be located in the vicinity of a car body such as an automobile or located on a plane so as to be integrated with the car body by disposing an earth terminal of the antenna on a conductive base plate connected with the earth terminal, and the antenna can be downsized so as to be equipped even in a small location. Thus, there can be provided a high-performance antenna device.

The foregoing description of the preferred embodiments of the invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed, and modifications and variations are possible in light of the above teachings or may be acquired from practice of the invention. The embodiments were chosen and described in order to explain the principles of the invention and its practical application to enable one skilled in the art to utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the claims appended hereto, and their equivalents.

Claims

1. An antenna device, comprising: one or more linear conductor each having at least one bent or curved portions for a feeder section.

2. An antenna device as claimed in claim 1, wherein the linear conductor has four or more even bent or curved portions.

3. An antenna device, comprising: one or more spiral linear conductor for the feeder section.

4. An antenna device as claimed in claim 1, 2 or 3, wherein there are two linear conductors for said feeder section, and the directions of bending, curving of the two linear conductors or spirally winding are identical with each other viewed from said feeder section.

5. An antenna device as claimed in claim 1, 2 or 3, wherein there are two linear conductors for said feeder section, and the directions of bending, curving of the two linear conductors or spirally winding are different from each other viewed from said feeder section.

6. An antenna device as claimed in claim 1, wherein a length of from the feeder section to a first bent point or a curved point is relatively longer or shorter than a length of from said first bent point or curved point to a second bent point or a curved point.

7. An antenna device which is disposed in the vicinity of a conductive base plate so that an earth terminal of the antenna is connected to said conductive base plate.

8. An antenna device which is disposed in the vicinity of a conductive base plate, wherein a switching element is disposed between an earth terminal of the antenna and the conductive base plate.

9. An antenna device as claimed in claim 7 or 8, wherein a feeding terminal of the antenna penetrates said conductive base plate so that electricity is fed from a side opposite to a side where said antenna is located.

10. An antenna device as claimed in claim 8, wherein connection switching control between the earth terminal of said antenna and said conductive base plate is conducted by using a switching element to obtain a desired directivity or polarization surface.

11. An antenna device as claimed in claim 8, wherein a polarization surface that obtains a maximum efficiency becomes horizontal polarization by turning on the switching element.

12. An antenna device as claimed in claim 8, wherein a polarization surface that obtains a maximum efficiency becomes vertical polarization by turning off the switching element.

13. An antenna device as claimed in any one of claims 8 to 12, wherein the connection switching of the switching element can be remotely controlled.

14. An antenna device as claimed in any one of claims 7 to 9, wherein the characteristic of the antenna is controlled to a desired characteristic by changing a distance between said antenna and said conductive base plate.

15. An antenna device as claimed in any one of claims 7 to 9, wherein the characteristic of the antenna is controlled to a desired characteristic by changing an angle between said antenna plane and said conductive base plate plane.

16. An antenna device as claimed in any one of claims 7 to 15, wherein a spacer is inserted between the antenna and said conductive base plate, and the spacer is made of a low-dielectric material.

17. An antenna device as claimed in any one of claims 7 to 16, wherein the conductive base plate is a part of a movable body, a part of a building, a part of a structural substance or a part of a radio using device.

18. An antenna device wherein the antenna is structured by an antenna element group where a plurality of antenna elements are unified at a single feeder section.

19. An antenna device as claimed in claim 18, wherein taps are formed at predetermined positions of a plurality of antenna elements, and joined together to form said single feeder section.

20. An antenna device as claimed in claim 18 or 19, wherein a plurality of antenna elements are identical in tuning frequency to obtain a predetermined antenna efficiency.

21. An antenna device as claimed in claim 18 or 19, wherein a plurality of antenna elements are antennas corresponding to a plurality of divided frequency bands obtained by dividing a desired frequency band, respectively, and a predetermined band is realized by said antenna element group.

22. An antenna device as claimed in claim 21, wherein the tuning frequencies of the respective antenna elements are set with a predetermined interval.

23. An antenna device as claimed in claim 18 or 19, wherein a covered frequency band is set to the upper or the lower than the tuning frequency when the respective antenna elements are single.

24. An antenna device as claimed in claim 18 or ,19, wherein the width of a set frequency band is adjusted by setting the number of antenna elements to be connected to a predetermined number.

25. An antenna device as claimed in claim 18 or 19, wherein, provided that any one antenna plane of said plurality of antenna elements is a reference plane, the arrangement state of said respective antenna elements is any one of a state where the respective antennas are close to each other or concentrated on the reference plane, a state where the respective antenna planes are disposed perpendicularly with respect to said reference plane so that the respective antenna planes are in the form of layers, or a state where the respective antenna planes are disposed vertically and shifted horizontally.

26. An antenna device as claimed in claim 18 or 19, wherein a longer antenna element is set to a relatively lower tuning frequency, whereas a shorter antenna element is set to a relatively higher tuning frequency.

27. An antenna device as claimed in claim 18 or 19, wherein a longer antenna element is disposed relatively outside, whereas a shorter antenna element is disposed relatively inside.

28. An antenna device as claimed in claim 18 or 19, wherein a balanced-to-unbalanced transformer is used for the feeder section of the antenna.

29. An antenna device as claimed in claim 18 or 19, wherein the feeder section of the antenna is connected with an active element or an amplifier element.

30. An antenna device as claimed in claim 18 or 19, wherein an impedance transformer is used to the feeder section of the antenna, a coil one end of which is grounded and the other of which is a feeding terminal is disposed closely, or a balanced coil is disposed closely.

31. An antenna device as claimed in claim 18 or 19, wherein an isolator is used to a feeder section of the respective antenna elements.

32. An antenna device as claimed in claim 19, wherein a direction of taking a tap is set arbitrarily for each of the antenna elements.

33. An antenna device as claimed in claim 19, wherein an electrode extending from a feeding terminal to the tap positions of the respective antenna elements is commonly used.

34. An antenna device as claimed in claim 33, wherein said common electrode is disposed in parallel with said antenna element.

35. An antenna device as claimed in claim 19, wherein the taps of the respective antenna elements are taken through a reactance element or a variable reactance element.

36. An antenna device as claimed in claim 35, wherein a predetermined impedance, a predetermined frequency band, a predetermined directivity or maximum efficiency is obtained by adjusting the reactance value of the respective antenna elements.

37. An antenna device wherein a tuning frequency is controlled by setting the coupling of opposed open terminal portions of an antenna element.

38. An antenna device in which a tuning frequency is controlled by setting the coupling of an open terminal side of an antenna element and a neutral point thereof or opposed portions thereof in the vicinity of the neutral point.

39. An antenna device as claimed in claim 37 or 38, wherein the coupling of the opposed portions is set by providing a predetermined distance therebetween.

40. An antenna device as claimed in claim 37 or 38, wherein the coupling of the opposed portions is set by connecting a concentration constant therebetween.

41. An antenna device wherein at least one linear conductor is connected to both poles of a coil, respectively, and an earth terminal is formed at the neutral point of the coil, and a tap is formed at a predetermined position of the respective linear conductors or the coil, from which a feeding terminal is led out.

42. An antenna device wherein one or two linear conductors are provided for a feeder section through a coil.

43. An antenna device as claimed in any one of claims 1 to 42, wherein the respective antenna elements are formed on the same substrate or a multi-layer substrate by printed wiring.

44. An antenna device as claimed in any one of claims 1 to 43, wherein at least one antenna is selected from a plurality of antennas under control.

45. An antenna device as claimed in claims 44, wherein an antenna maximum in a receiver input is selected under control in the control for selecting a plurality of antennas.

46. An antenna device as claimed in claim 44, wherein an antenna minimum in multipath interference level is selected under control in the control for selecting a plurality of antennas.

47. An antenna device as claimed in any one of claims 1 to 46, wherein the antenna element is disposed in a recess of the conductive base plate.

48. An antenna device as claimed in any one of claims 7 to 17, wherein the conductive base plate comprises a plate which is mesh-shaped or has at least one through-hole.

49. An antenna device, comprising:

a main antenna element a predetermined portion of which is grounded;
at least one antenna element which is disposed close to the main antenna element, which is relatively shorter than the main antenna element, and both ends of which are not grounded; and
at least one antenna element which is disposed close to the main antenna element, which is relatively longer than the main antenna element, and both ends of which are not grounded.

50. An antenna device as claimed in claim 49, wherein the antenna element is of the monopole type or dipole type.

51. An antenna device as claimed in claim 49 or 50, wherein the respective antenna element are formed

on a printed board by a printed wiring method.

52. An antenna device as claimed in claim 7, wherein the size of the conductive base plate is substantially equal to or smaller than the size of said antenna element plane.

53. An antenna device as claimed in claim 52, wherein the conductive base plate is not connected to another earth member which is in the vicinity of the conductive base plate.

54. An antenna device as claimed in any one of claims 7 to 17, wherein a distance between the conductive base plate and said antenna element is set to 0.01 to 0.25 times (that is, 0.01λ to 0.25λ) as large as the wavelength λ in the resonance frequency f of the antenna.

55. An antenna device as claimed in any one of claims 7 to 17, wherein, in the case where a plurality of antenna elements are disposed, a distance between said conductive base plate and said respective antenna elements is set to 0.01 to 0.25 times (that is, 0.01λ to 0.25λ) as large as the wavelength λ in the resonance frequency f of the respective antennas for each of the antenna element.

56. An antenna device as claimed in any one of claims 7 to 17, wherein a high dielectric factor member is disposed between the conductive base plate and said antenna element.

57. An antenna device as claimed in claim 44, wherein a plurality of antennas are located at a plurality of positions of a car body pillar portion and a roof member of an automobile, and diversity structure is comprised of the plurality of antennas.

58. An antenna device, comprising:

a conductive base plate; and
an antenna element an earth portion of which is connected to the conductive base plate and disposed close to the conductive base plate;
wherein at least a region of said conductive base plate which is opposed to said antenna element is disposed on a communication counterpart side with respect to said antenna element.

59. An antenna device as claimed in claim 58, wherein the conductive base plate substantially surrounds the periphery of said antenna element.

60. An antenna device as claimed in claim 58 or 59, wherein the conductive base plate is a part of any one of a movable body, a building, a structural substance, and a radio using device.

61. An antenna device, comprising:

a conductive base plate;
an antenna element an earth portion of which is connected to the conductive base plate and which is disposed close to the conductive base plate; and
rotating means for rotating said conductive base plate and said antenna element without any change of its arrangement state.

62. An antenna device, comprising:

a conductive base plate;
an antenna element an earth portion of which is connected to the conductive base plate and which is disposed close to the conductive base plate; and
ferroelectrics disposed in the periphery of said antenna element between said conductive base plate and said antenna element.

63. An antenna device as claimed in claim 62, wherein the ferroelectrics are movable.

64. An antenna device, comprising:

a conductive base plate; and
an antenna element an earth portion of which is connected to the conductive base plate and which is disposed close to the conductive base plate;
wherein said antenna element is shaped along the configuration of said conductive base plate.

65. An antenna device as claimed in claim 64, wherein the antenna element is disposed inside of said conductive base plate.

66. An antenna device, comprising:

a conductive base plate; and
a plurality of antenna elements an earth portion of which is connected to the conductive base plate, which are disposed close to the conductive base plate in correspondence with the tuning frequencies of plural bands, and which is different in length from each other; and a plurality of feeder sections disposed on each of the plurality of antenna elements.

67. An antenna device, comprising:

a conductive base plate; and
an antenna element an earth portion of which

is connected to the conductive base plate and which is disposed close to the conductive base plate;

wherein said conductive base plate is a part that forms a substantially vertical wall of an automobile, and the electric field of the antenna element is formed substantially horizontally.

68. An antenna device, comprising:

a conductive base plate; and
an antenna element an earth portion of which is connected to the conductive base plate and which is disposed close to the conductive base plate;

wherein said conductive base plate is a part that forms a substantially horizontal wall of an automobile, and the electric field of the antenna element is formed substantially vertically.

69. An antenna device, comprising:

a conductive base plate; and
an antenna element an earth portion of which is connected to the conductive base plate and which is disposed close to the conductive base plate;

wherein said conductive base plate is a part of a housing wall of a movable unit, and the antenna element is disposed inside of said housing wall.

70. An antenna device, comprising:

a conductive base plate; and
an antenna element disposed close to the conductive base plate;

wherein a predetermined portion of said antenna element is formed of a coil or zigzag-shaped conductor; and wherein one end of said antenna element is grounded to said conductive base plate.

71. An antenna device as claimed in claim 70, wherein, in the case where said coil or zigzag-shaped conductor is formed on the end portion of said antenna element, said coil or zigzag-shaped conductor are connected to another portion of said antenna element on an insulator disposed on said conductive base plate.

72. An antenna device, comprising:

a conductive base plate; and
at least two antenna elements which are disposed close to the conductive base plate and different in length from each other;

wherein the respective predetermined portions of said antenna elements are formed of coil or zigzag-shaped conductor; and wherein the respective one ends of said antenna elements are commonly grounded to said conductive base plate.

73. An antenna device, comprising:

a conductive base plate;
at least two antenna elements which are disposed close to the conductive base plate and different in length from each other; and
a coil or zigzag-shaped conductor connected to a common connection point of the respective ends of the antenna elements;

wherein the other end of said coil or zigzag-shaped conductor is grounded to said conductive base plate.

74. An antenna device as claimed in claim 73, wherein said coil or zigzag-shaped conductor and other portion of said antenna element are connected on an insulator disposed on said conductive base plate.

75. An antenna device as claimed in claim 71 or 75, wherein said coil or zigzag-shaped conductor is divided into two pieces, the connection of said divided two portions is conducted on an insulator which is disposed on said conductive base plate, and the feeder section is connected to the connection portion.

76. An antenna device wherein an antenna element is wholly formed of a coil or zigzag-shaped conductor and formed in a shape having at least one bent or curved portion.

77. An antenna device, comprising:

a conductive base plate; and
an antenna element one end of which is grounded to the conductive base plate and which is disposed close to the conductive base plate;

wherein a feeder section is connected to an insulator disposed on said conductive base plate as a junction point.

78. An antenna device, comprising:

a conductive base plate; and
an antenna element one end of which is grounded to the conductive base plate and which is disposed close to the conductive base plate;

wherein a through-hole is formed in said conductive base plate, an insulator is disposed

on said conductive base plate at a side opposite to said antenna element of the through-hole, and a feeder section is connected on said insulator through said through-hole.

79. An antenna device as claimed in claim 78, wherein at least one different insulator is disposed at a side where said insulator of said conductive base plate is provided, and circuit component is connected between the different insulator and said insulator.

80. An antenna device, comprising:

a conductive base plate;
an antenna element disposed close to the conductive base plate; and
a conductive case disposed between the antenna element and said conductive base plate and having a through-hole at a predetermined portion;
wherein one end of said antenna element is grounded to said conductive case, a feeder section is connected through said through-hole to one of a plurality of insulators disposed on said conductive base plate within said conductive case, and a circuit component is connected on said plurality of insulators.

81. An antenna device, comprising:

a conductive base plate;
an insulating plate disposed close to the conductive base plate;
an antenna element formed on said insulating plate at a side far from said conductive base plate;
a conductor A that penetrates said insulating plate from the antenna element; and
a conductor B connected to the conductor A and formed on a surface opposite to a surface on which said antenna element of said insulating plate is formed;
wherein one end of said antenna element is grounded to said conductive base plate, and the feeder section is connected in the vicinity of said one end of said conductor B which is grounded.

82. An antenna device, comprising:

a conductive base plate;
an insulating plate disposed on the conductive base plate;
a conductive plate disposed on the insulating plate and smaller in area than said conductive base plate; and
an antenna element disposed close to the conductive plate, one end of which is grounded to said conductive plate.

83. An antenna device as claimed in claim 82, wherein an area of said conductive plate and an area of said antenna element are substantially identical with each other.

84. An antenna device as claimed in any one of claims 72 to 75, wherein said at least two antenna elements are unified by a single feeder.

85. An antenna device as claimed in claim 84, wherein said at least two antenna elements comprise antennas corresponding to a plurality of division frequency bands obtained by dividing a target frequency band, respectively, wherein a desired frequency band is realized by said antenna element groups.

86. An antenna device comprising

a conductive base plate on which a conductive plate which is used for earthing,
an antenna element which is provided near said conductive base plate and one edge of which is connected to said conductive plate.

87. An antenna device as claimed claim 86 ,wherein
a plane of the antenna element and the base plate are substantially provided in parallel to each other.

88. An antenna device as claimed claim 86 or 87,wherein
an area of plane of the antenna element and an area of the base plate are substantially same to each other.

Fig. 1 (a)

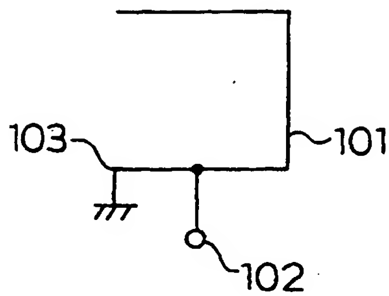


Fig. 1 (b)

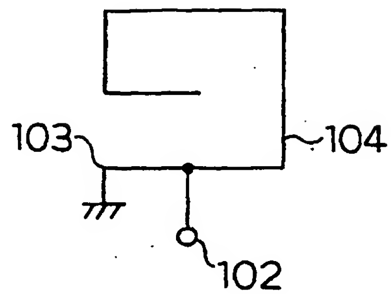


Fig. 2 (a)

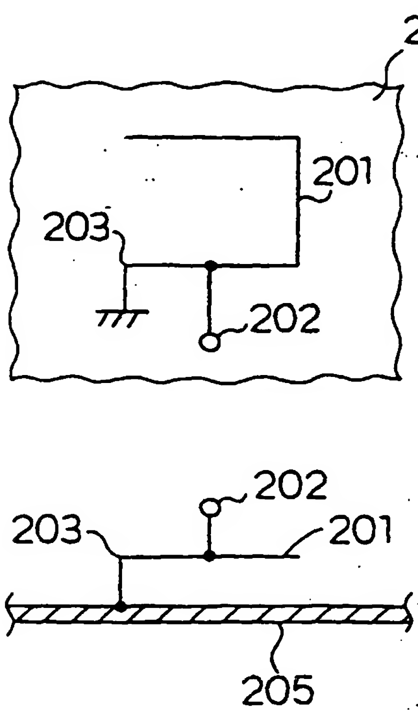


Fig. 2 (b)

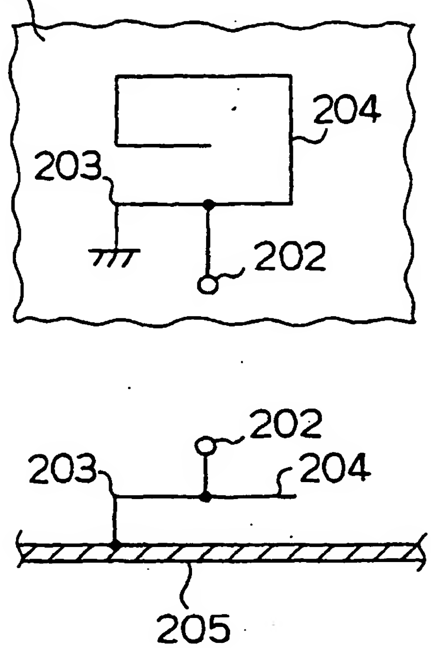


Fig. 3 (a)

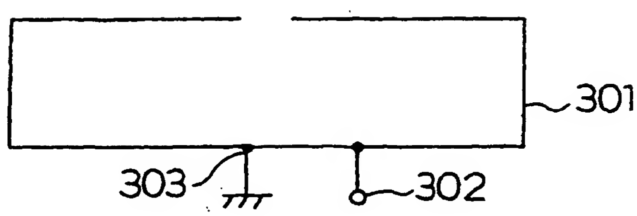


Fig. 3 (b)

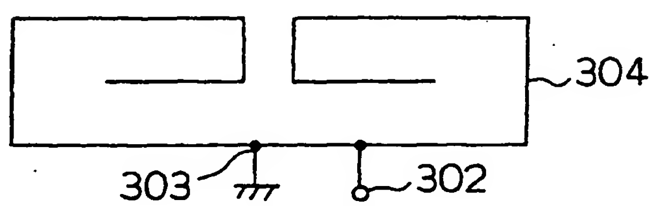


Fig. 4 (a)

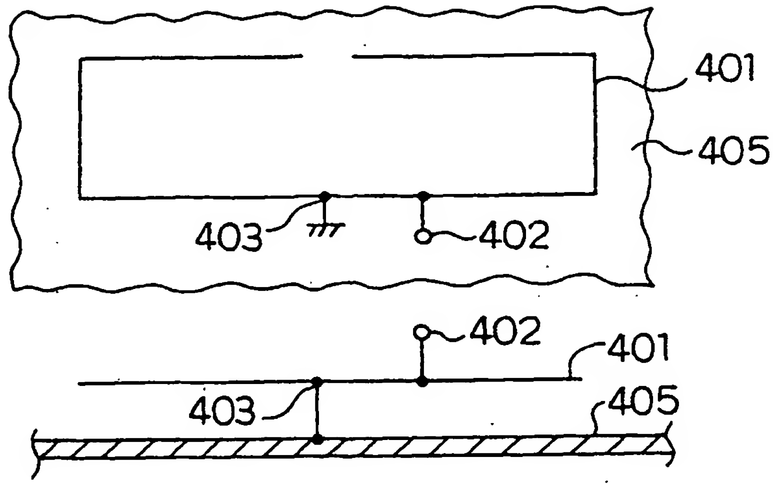


Fig. 4 (b)

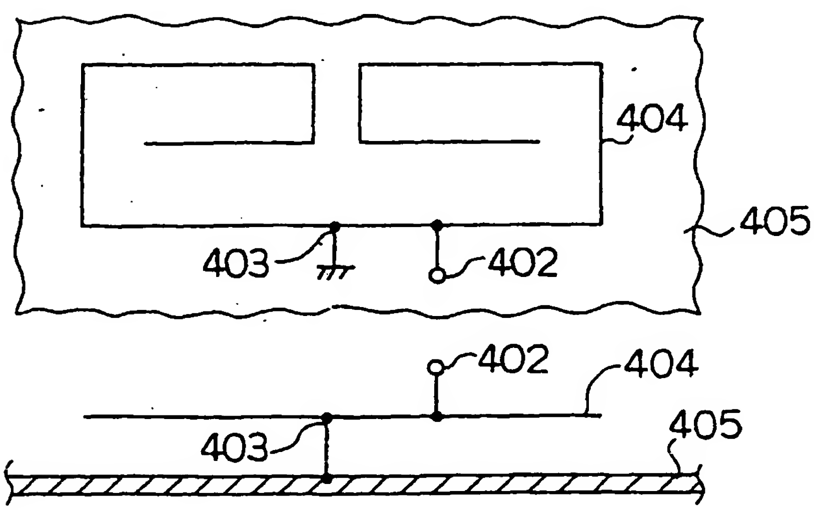


Fig. 5 (a)

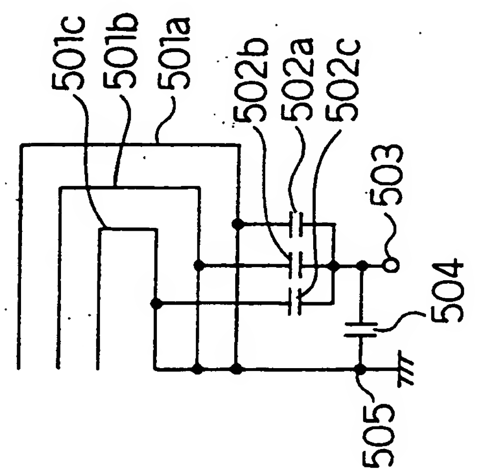
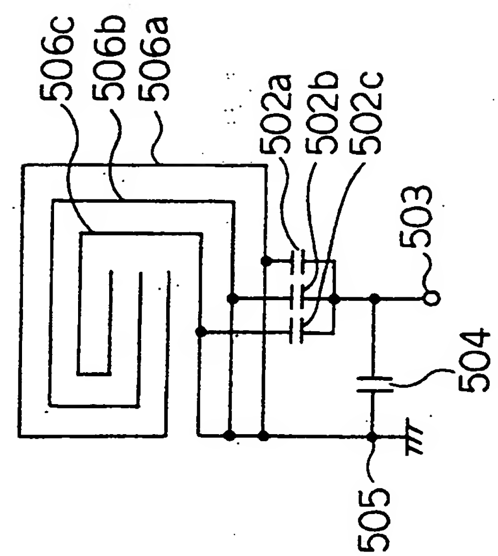
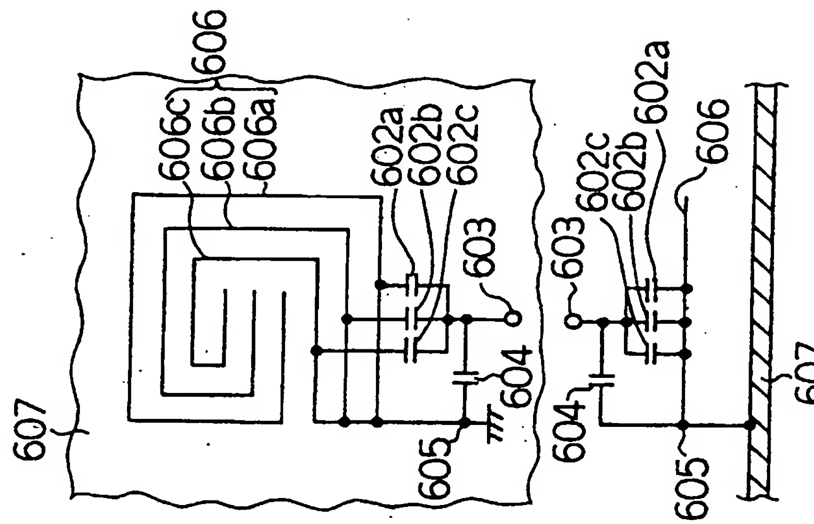

501c
501b
501a
502b
502a
502c
503
504
505

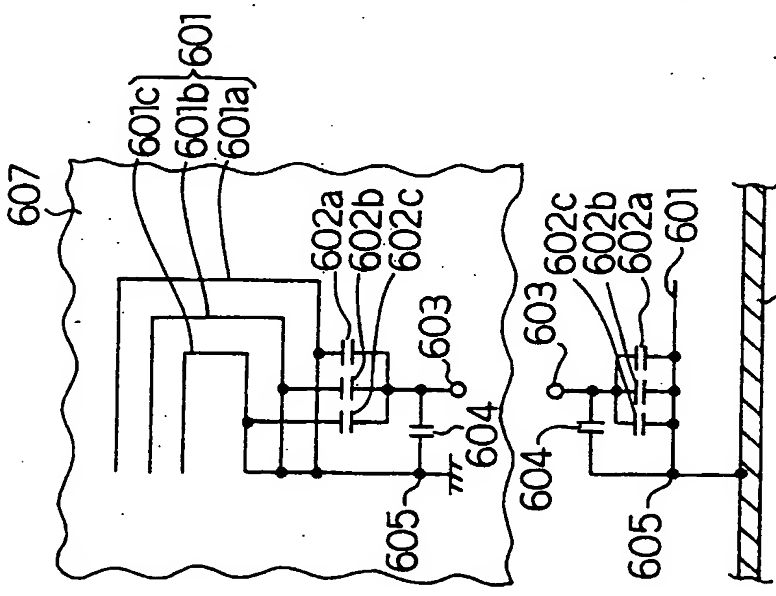
Fig. 5 (b)


506c
506b
506a
502a
502b
502c
503
504
505



607
606c
606b
606a
606
602a
602b
602c
603
604
605

Fig. 6 (b)



607
601c
601b
601a
601
602a
602b
602c
603
604
605

Fig. 6 (a)

Fig. 7 (a)

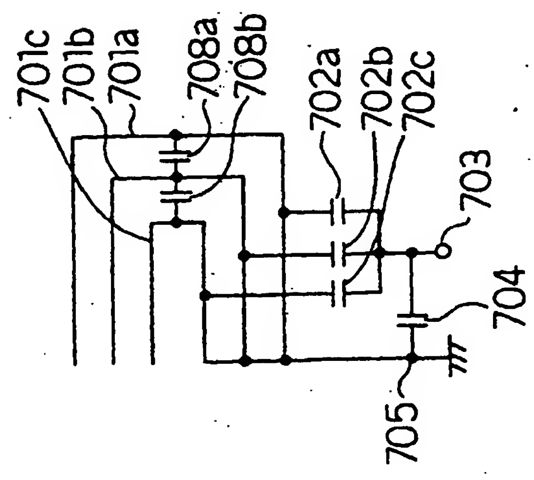

701c
701b
701a
708a
708b
702a
702b
702c
703
704
705

Fig. 7 (b)

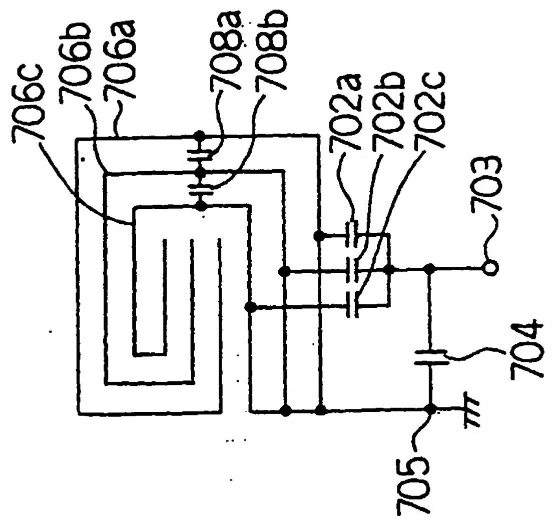

706c
706b
706a
708a
708b
702a
702b
702c
703
704
705

Fig. 8 (a)

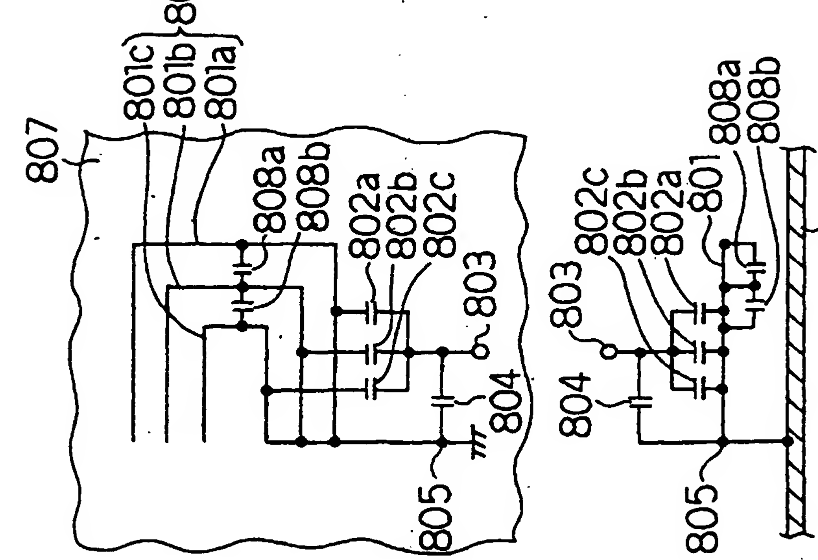
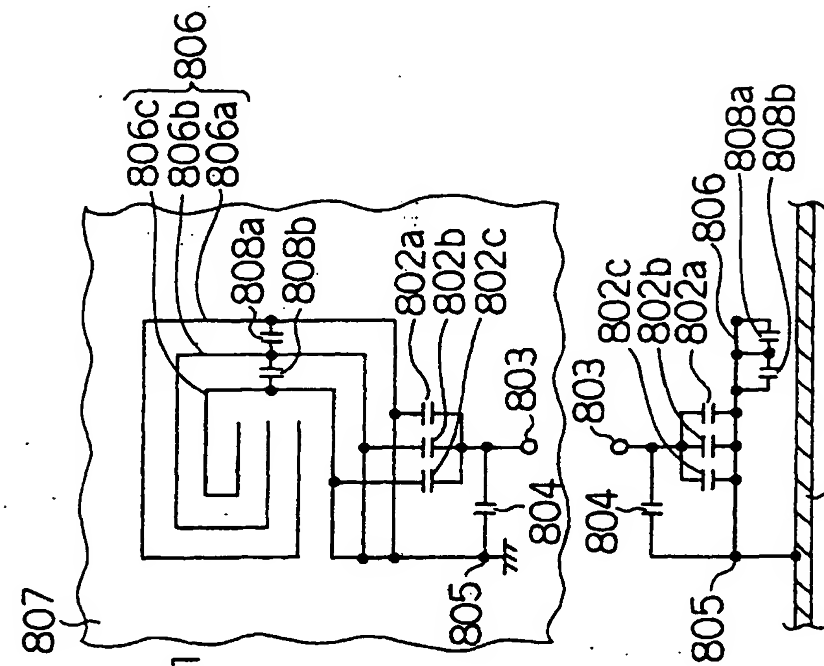

807
801c
801b
801a
801
808a
808b
802a
802b
802c
803
804
805
802c
802b
802a
801
808a
808b
803
804
805
807

Fig. 8 (b)


806c
806b
806a
806
807
808a
808b
802a
802b
802c
803
804
805
802c
802b
802a
806
808a
808b
803
804
805
807

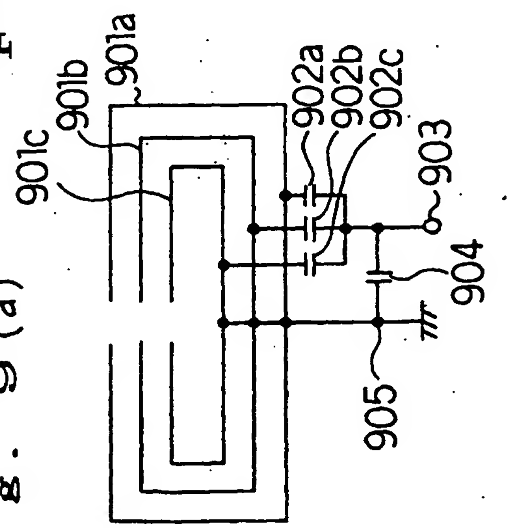

901a
901b
901c
902a
902b
902c
903
904
905

Fig. 9(a)

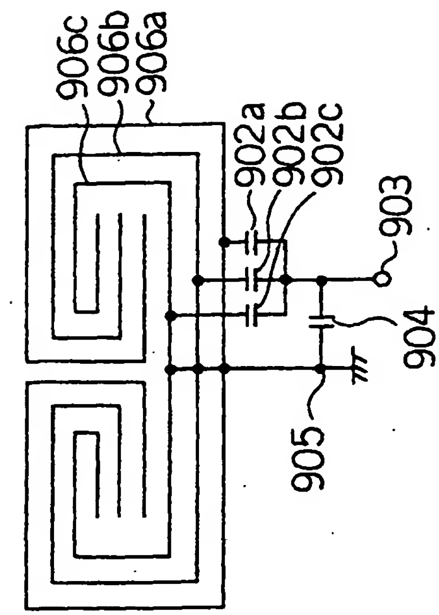

906c
906b
906a
902a
902b
902c
903
904
905

Fig. 9(b)

Fig. 10 (a)

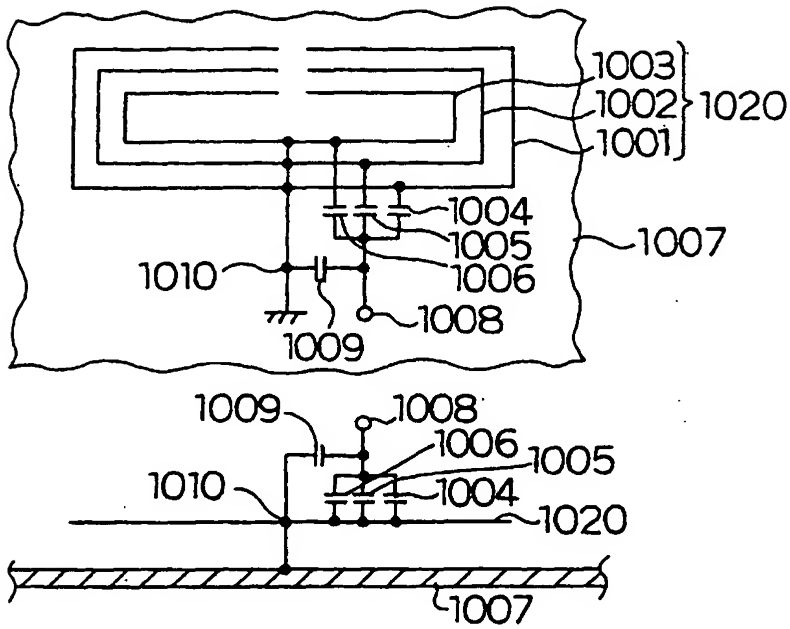


Fig. 10 (b)

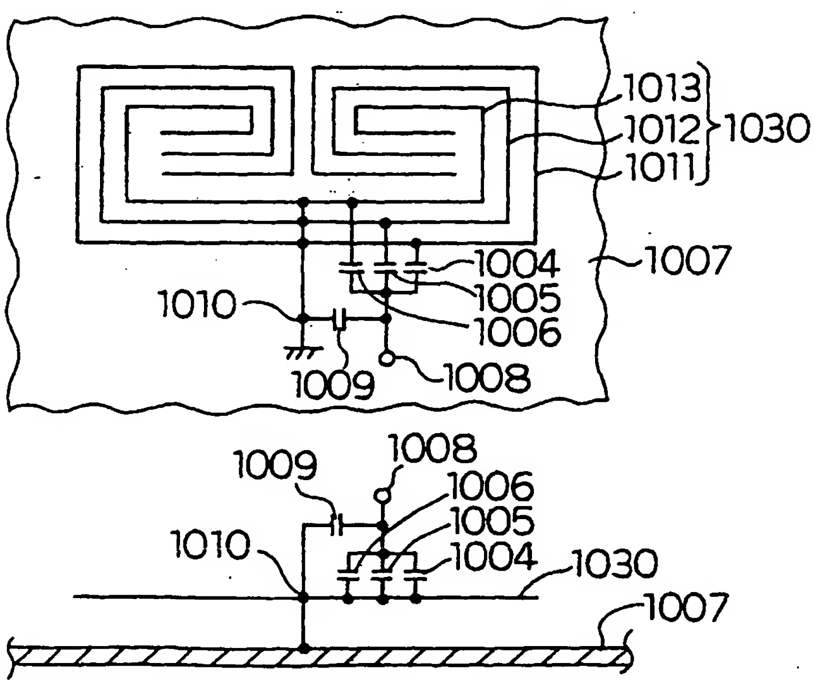


Fig. 11(b)

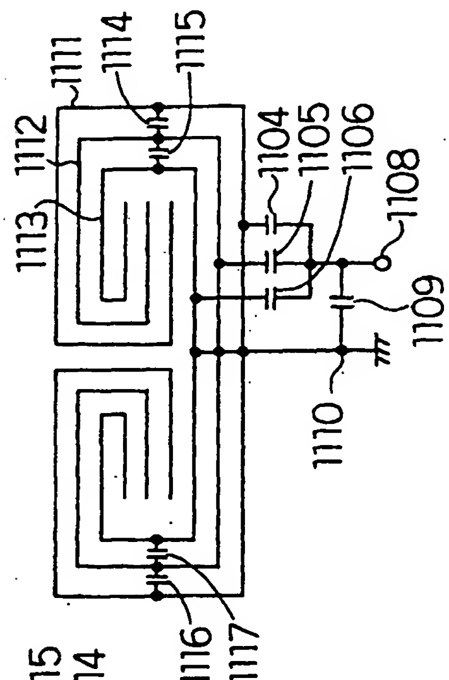


Fig. 11(a)

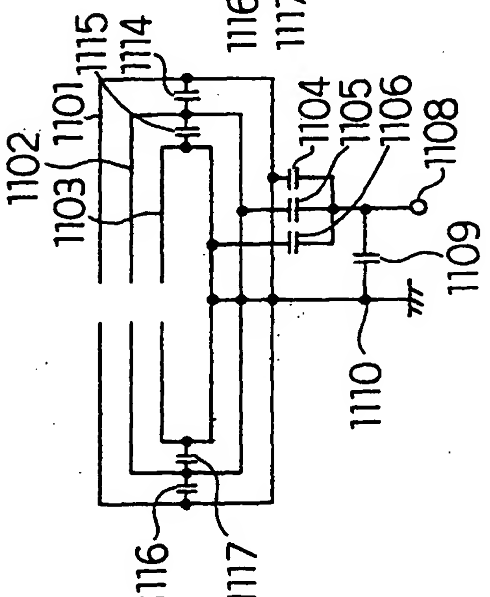


Fig. 12(a)

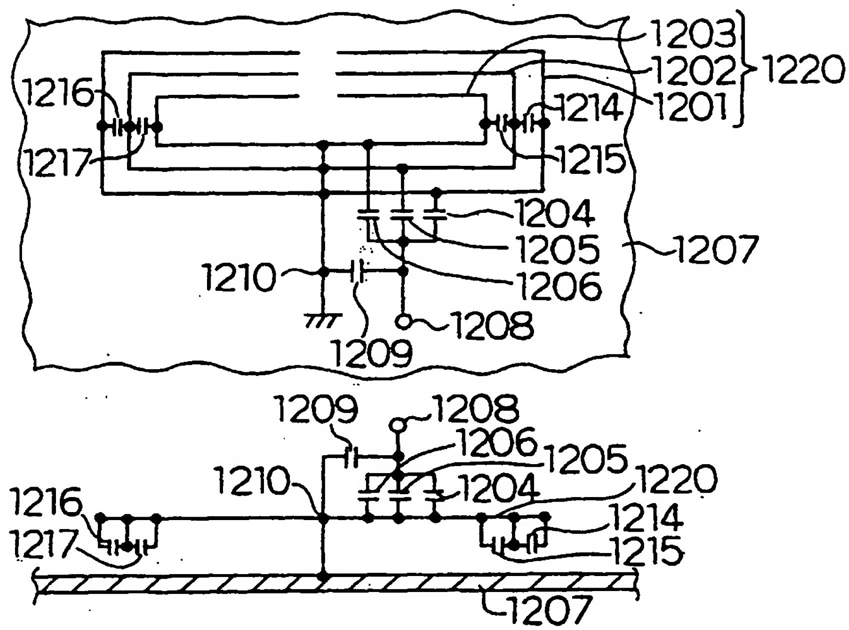


Fig. 12(b)

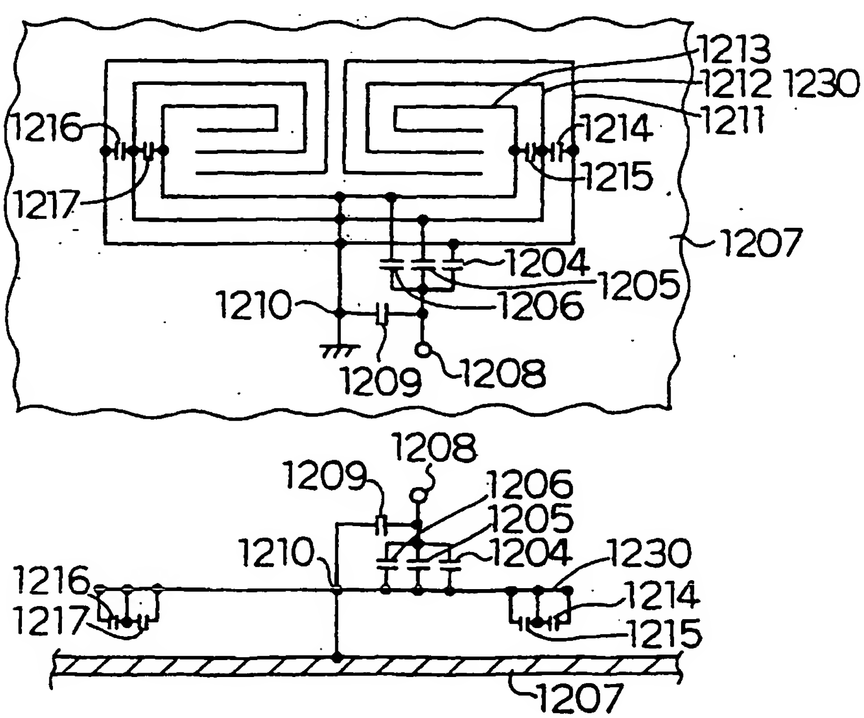


Fig. 13 (a)

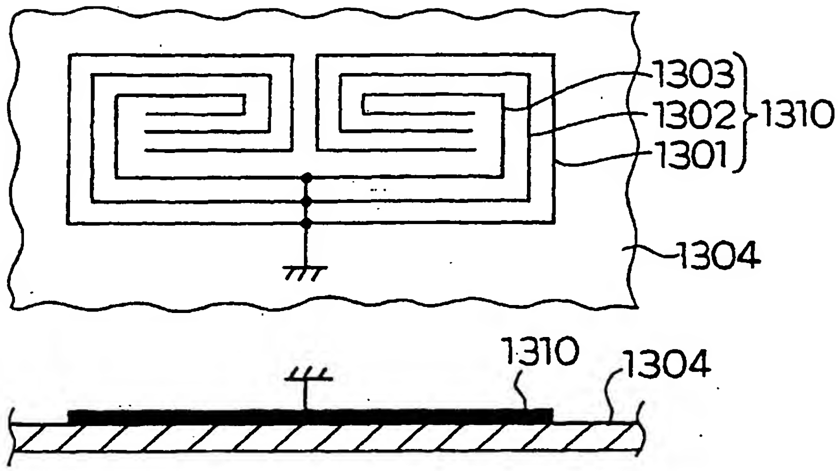


Fig. 13 (b)

(b)

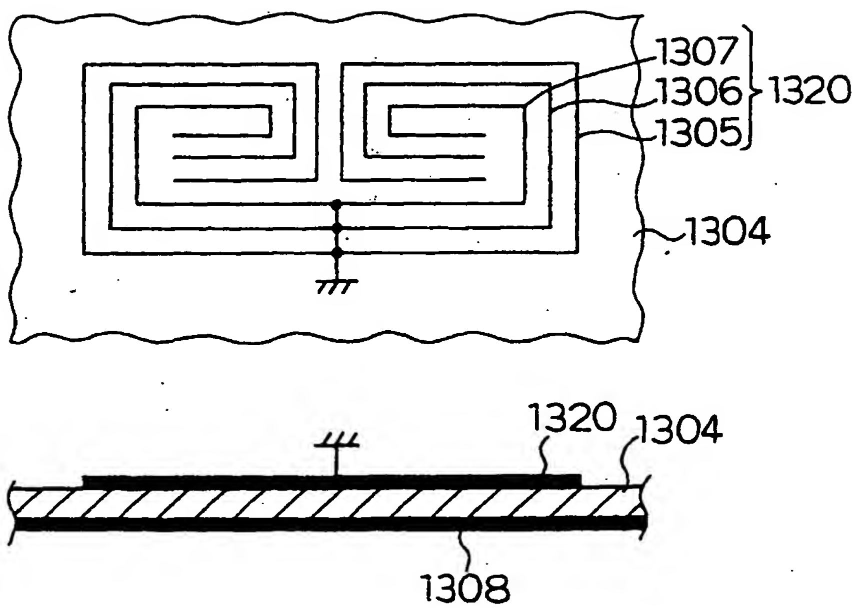


Fig. 14(a)

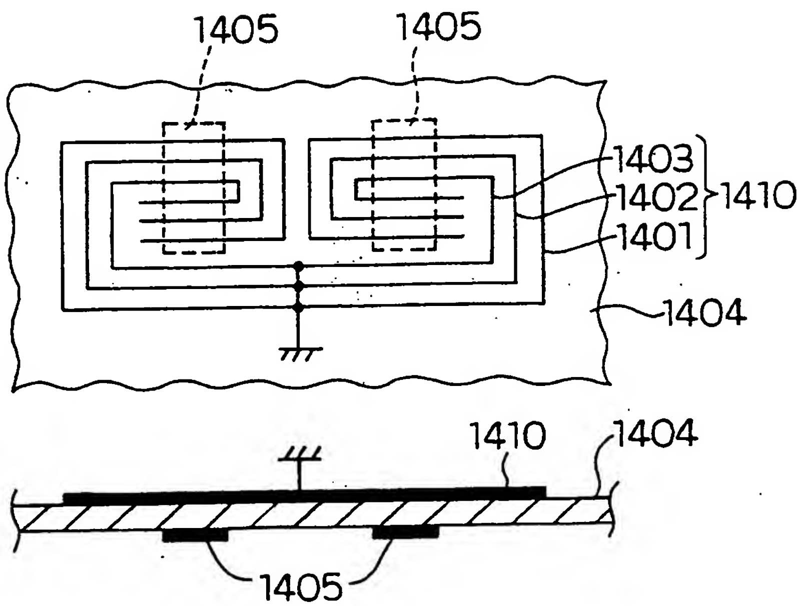


Fig. 14(b)

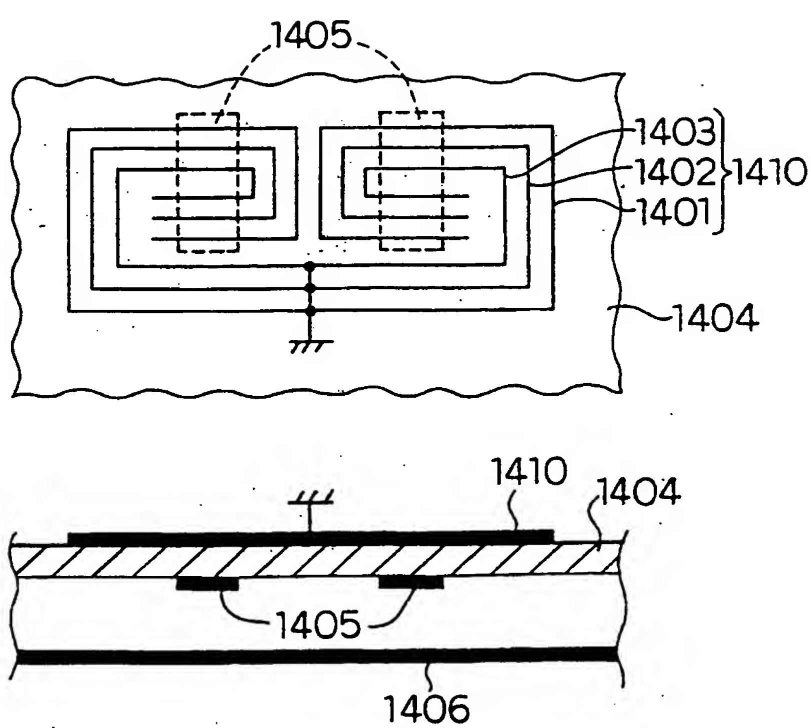
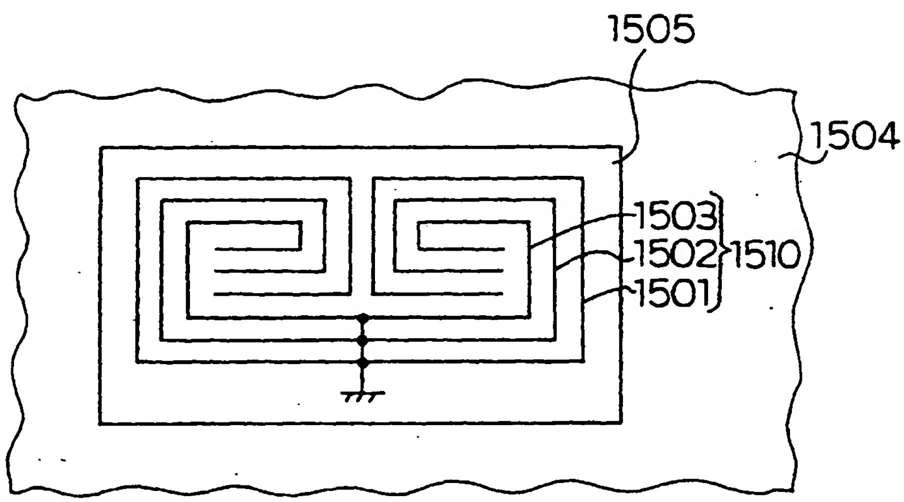


Fig. 15



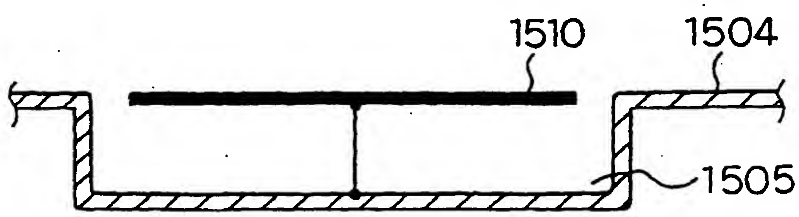


Fig. 16(a)

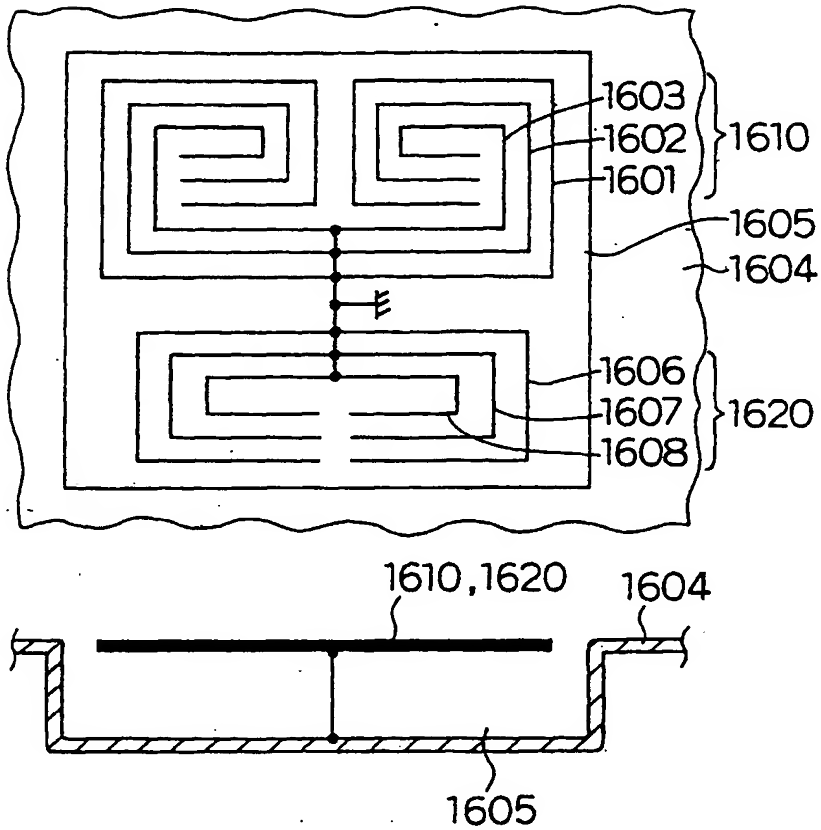


Fig. 16(b)

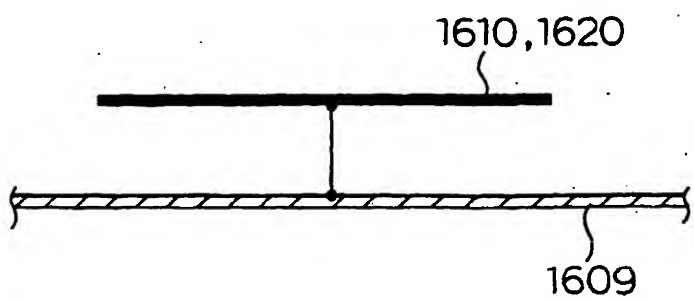


Fig. 17 (a)

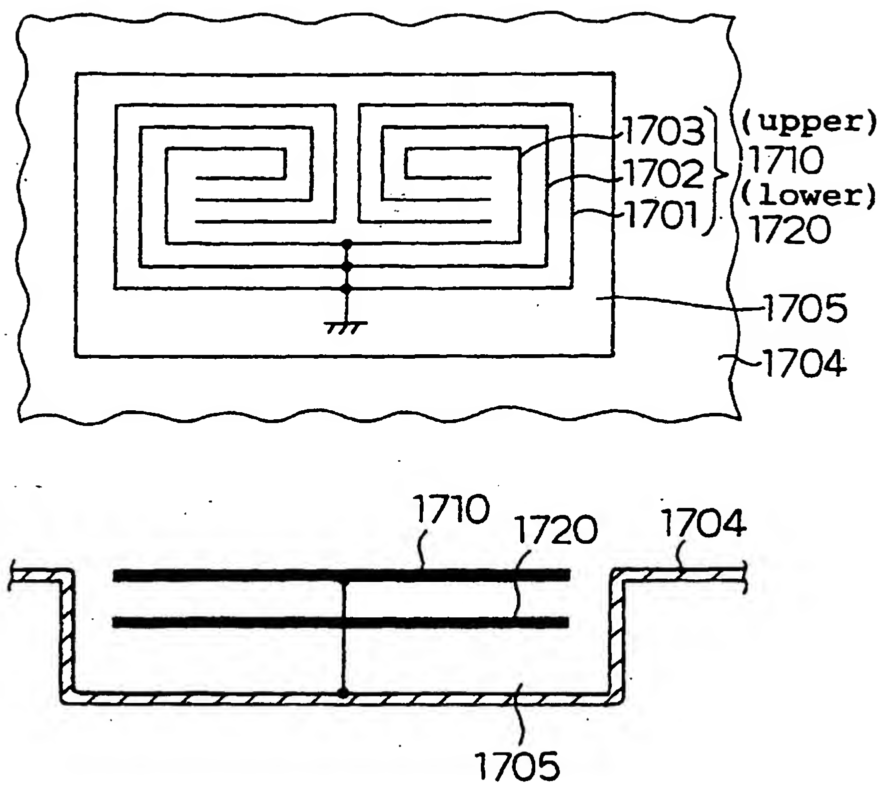


Fig. 17 (b)

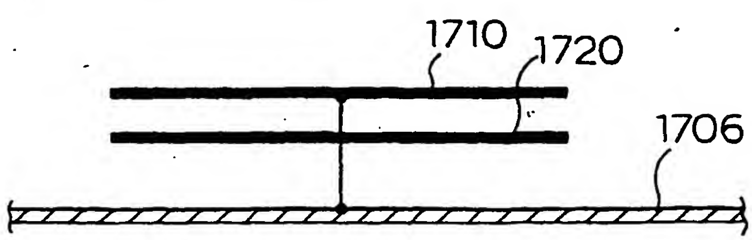


Fig. 18 (a)

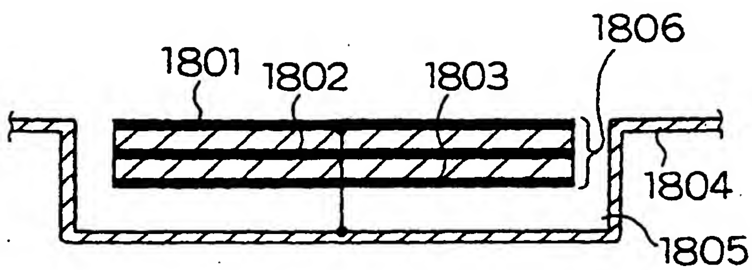


Fig. 18 (b)

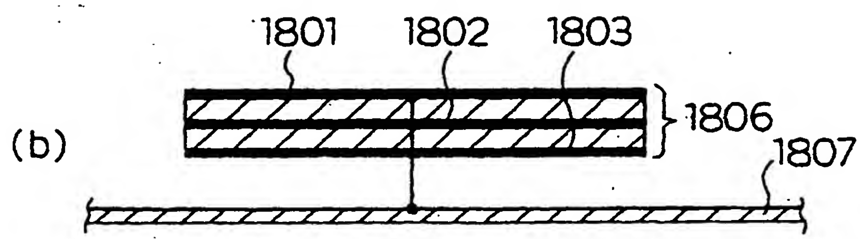


Fig. 19 (a)

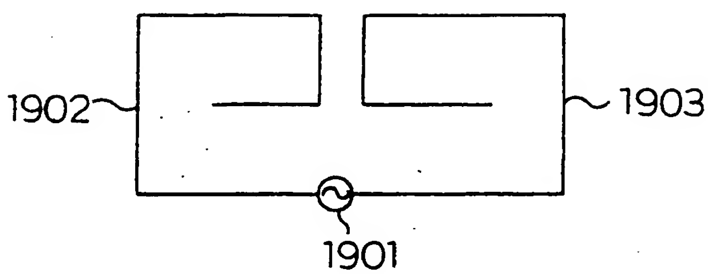


Fig. 19 (b)

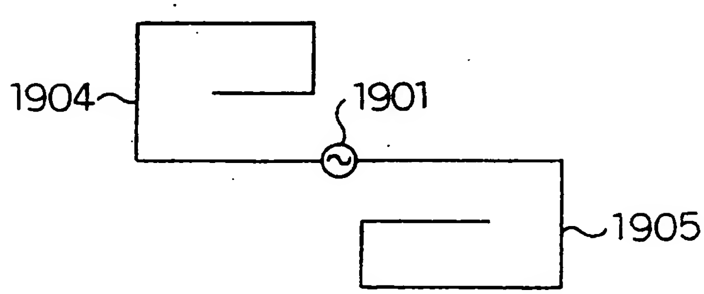


Fig. 20 (a)

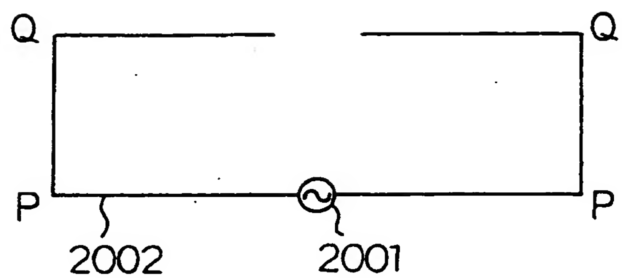


Fig. 20 (b)

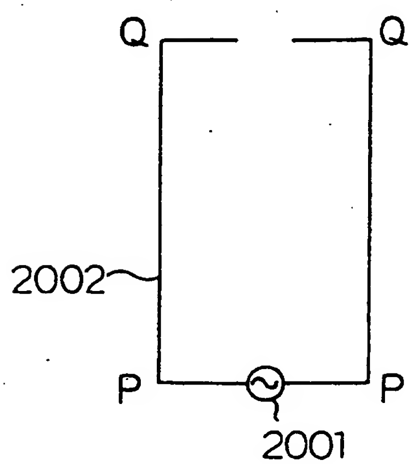


Fig. 21 (a)

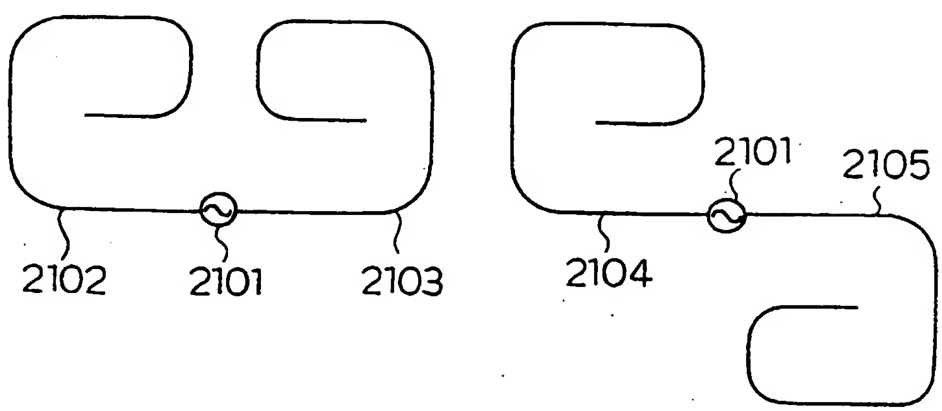


Fig. 21 (b)

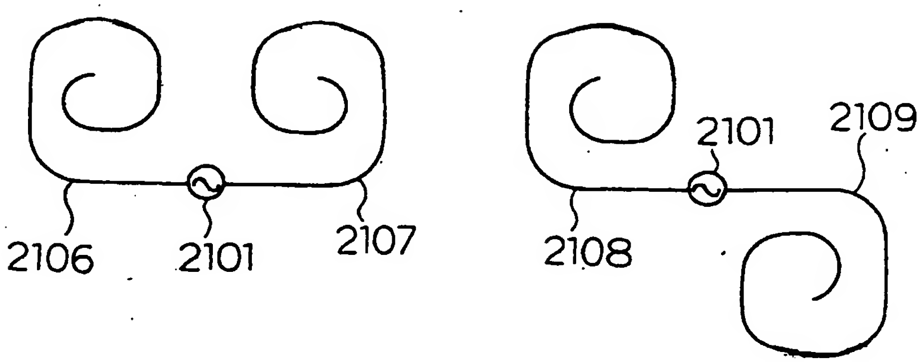


Fig. 22(a)

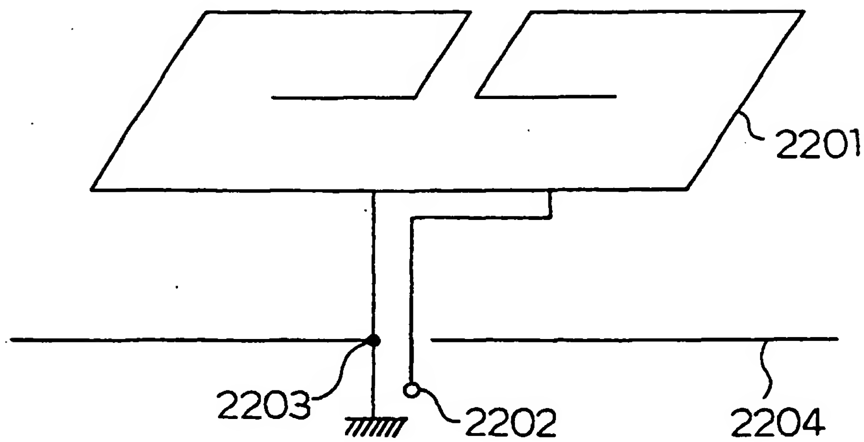


Fig. 22(b)

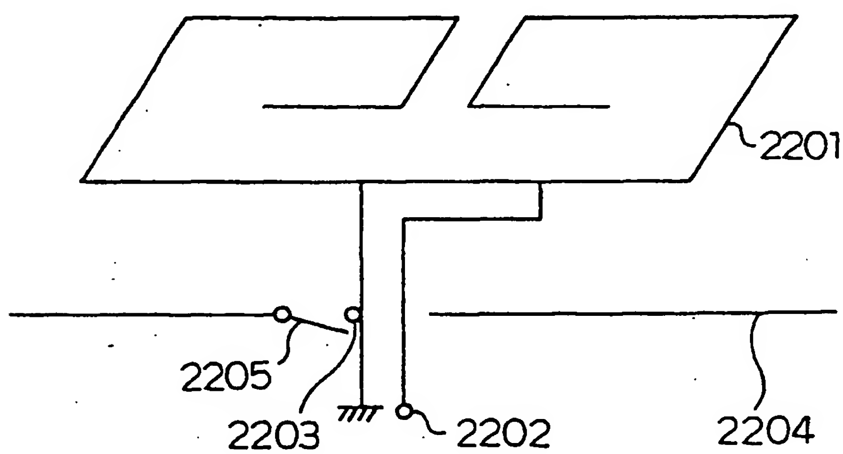


Fig. 23

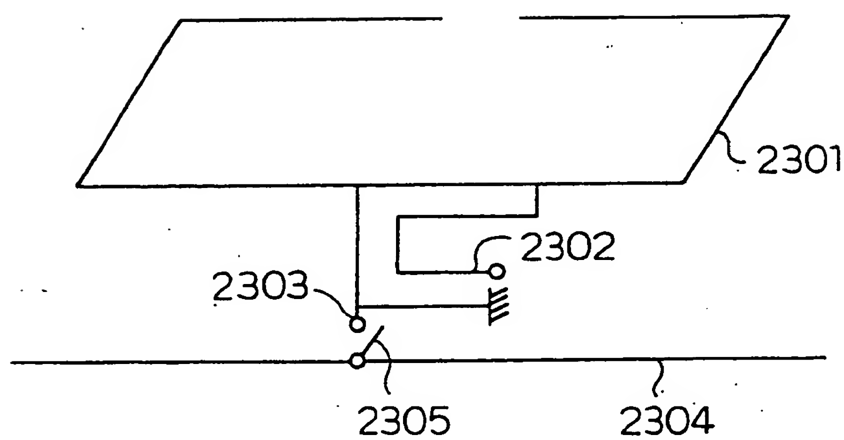


Fig. 24 (a)

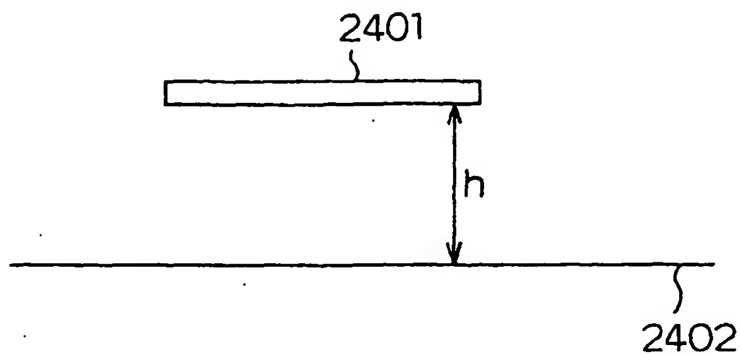


Fig. 24 (b)

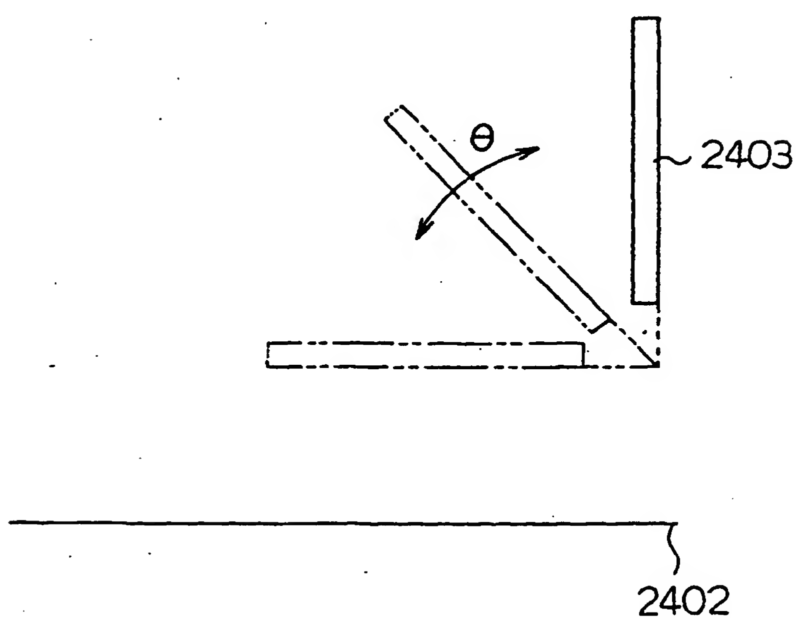


Fig. 25 (a)

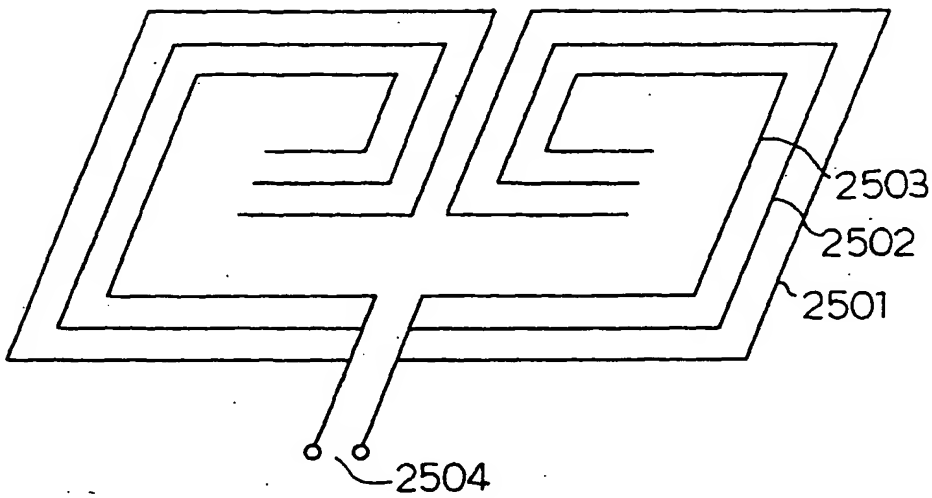


Fig. 25 (b)

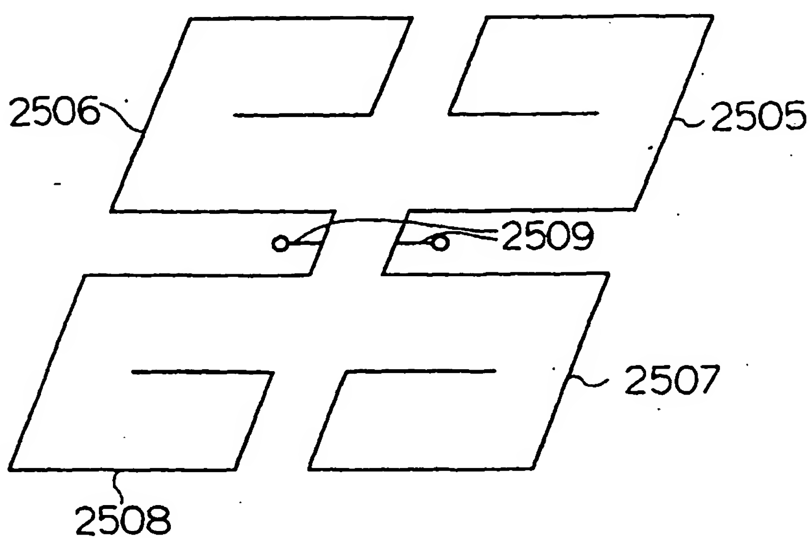


Fig. 26 (a)

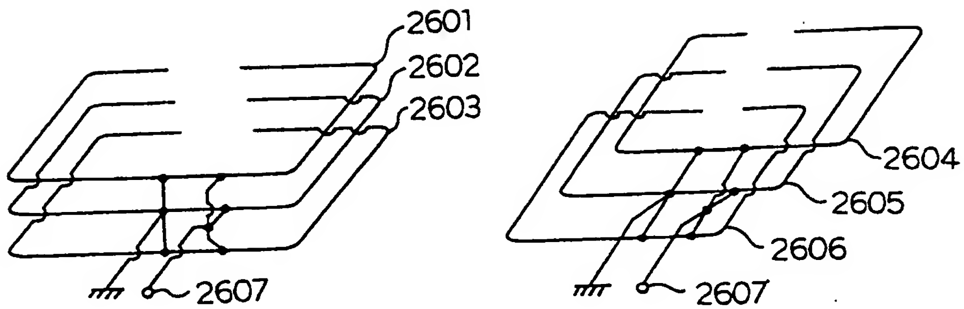


Fig. 26 (b)

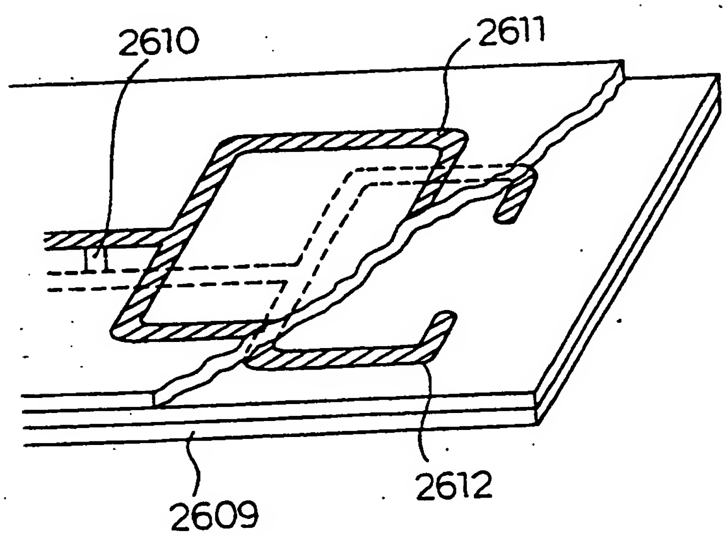


Fig. 27(a)

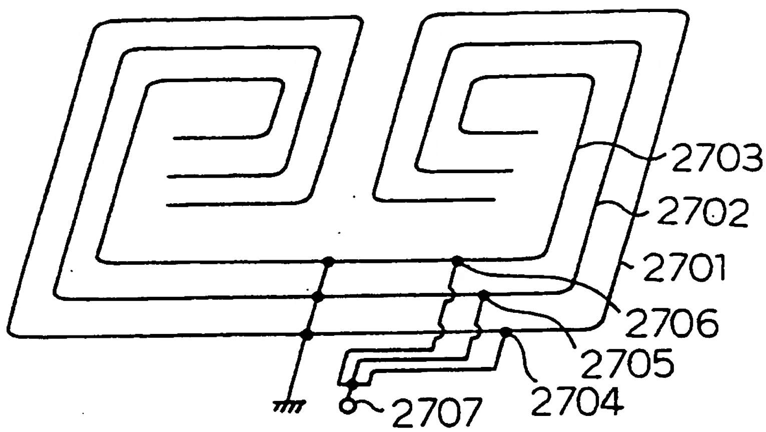


Fig. 27(b)

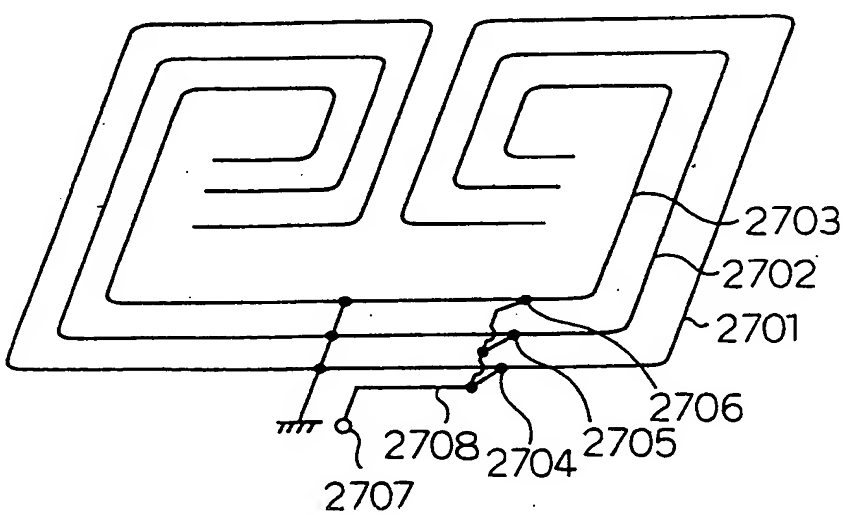


Fig. 28(a)

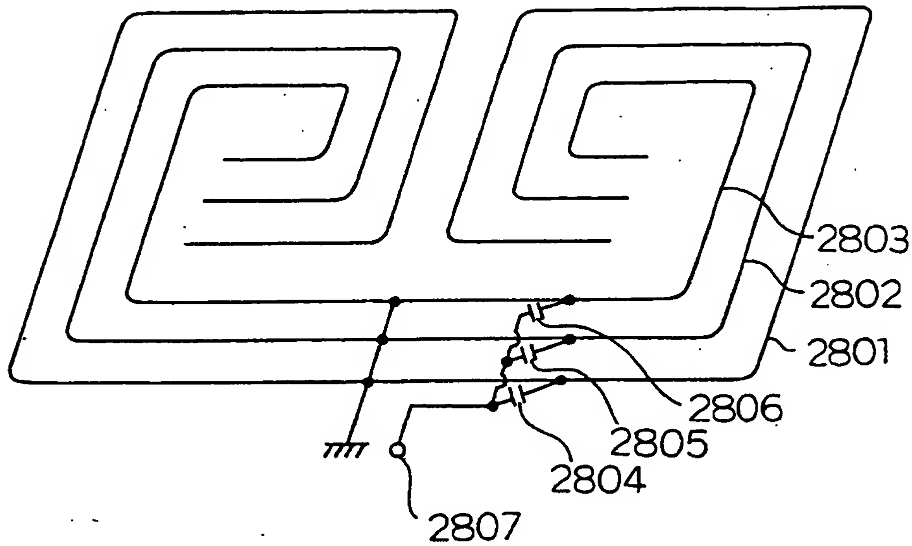
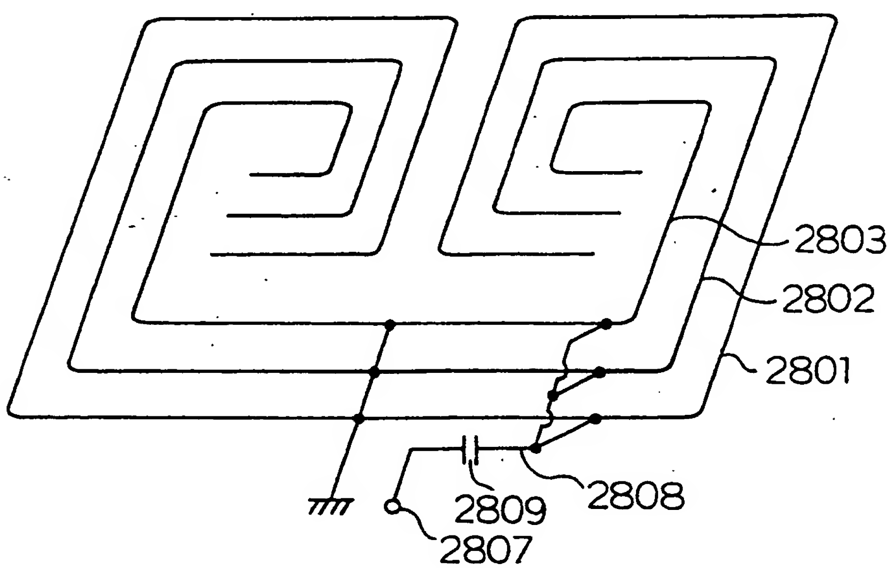


Fig. 28(b)



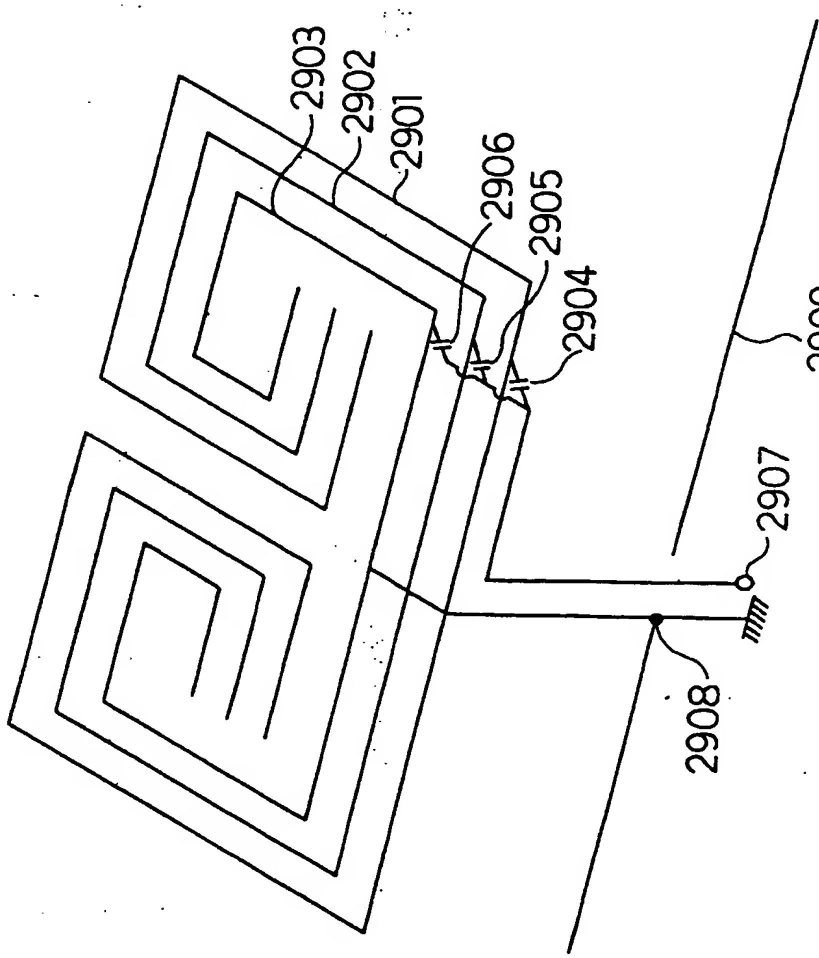


Fig. 29

Fig. 30 (a)

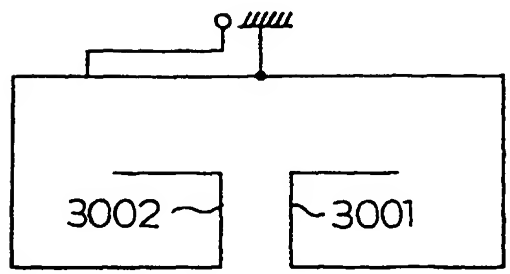


Fig. 30 (b)

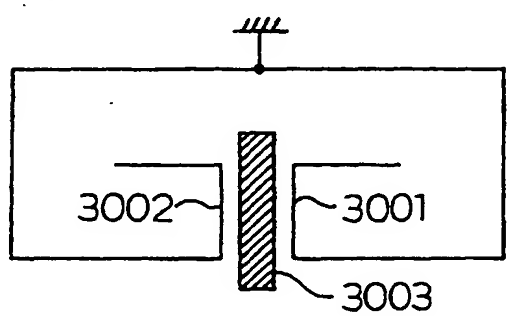


Fig. 30 (c)

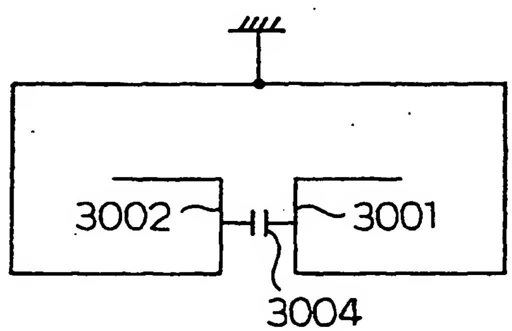


Fig. 31(a)

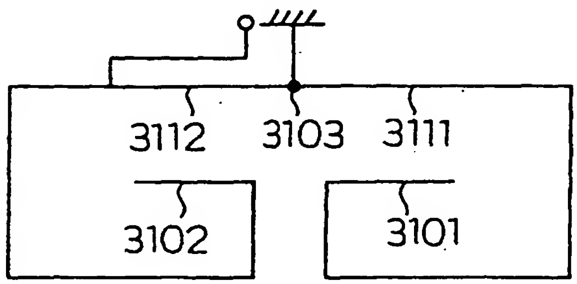


Fig. 31(b)

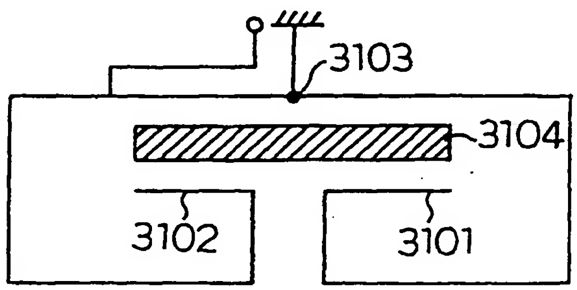


Fig. 31(c)

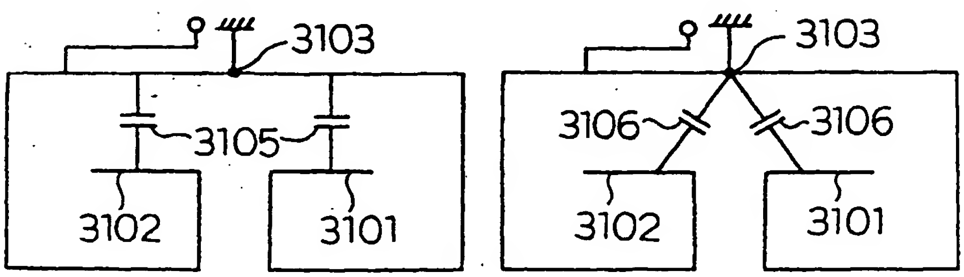


Fig. 32 (a)

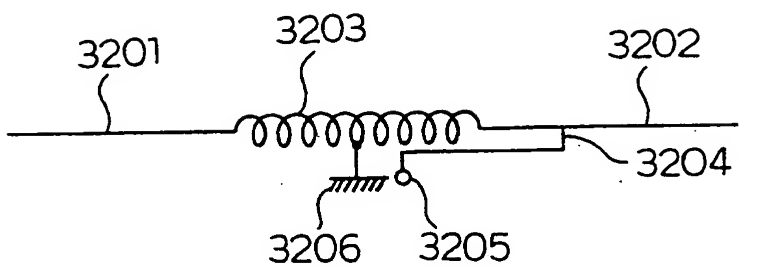


Fig. 32 (b)

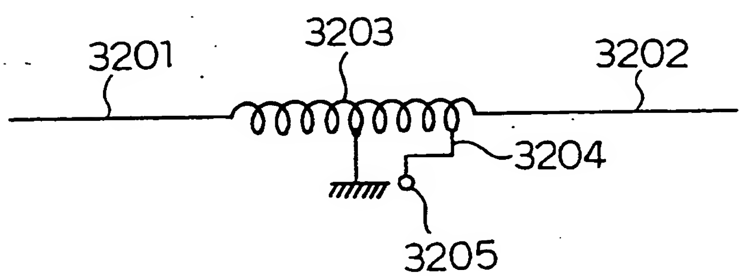


Fig. 33 (a)

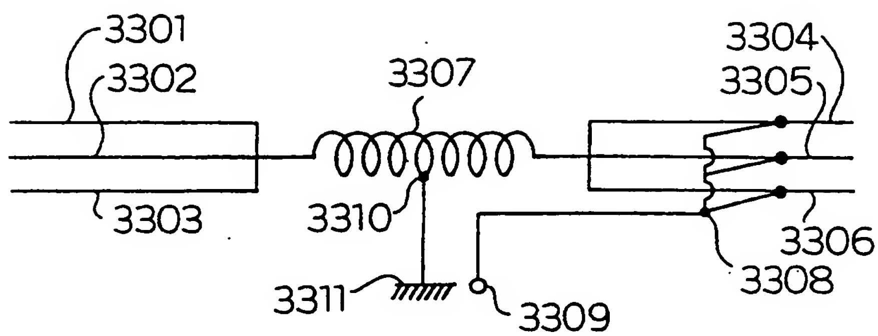


Fig. 33 (b)

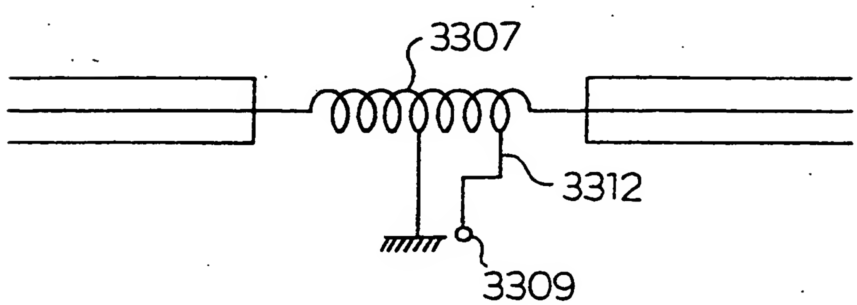


Fig. 34

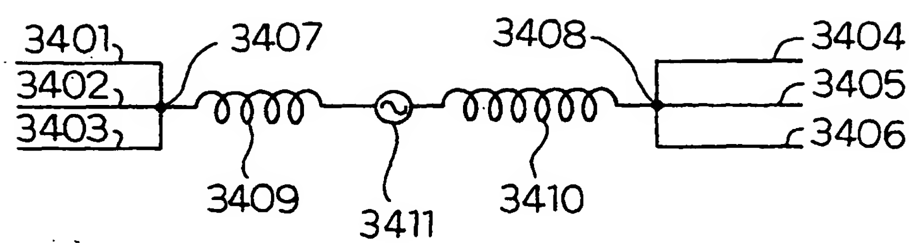
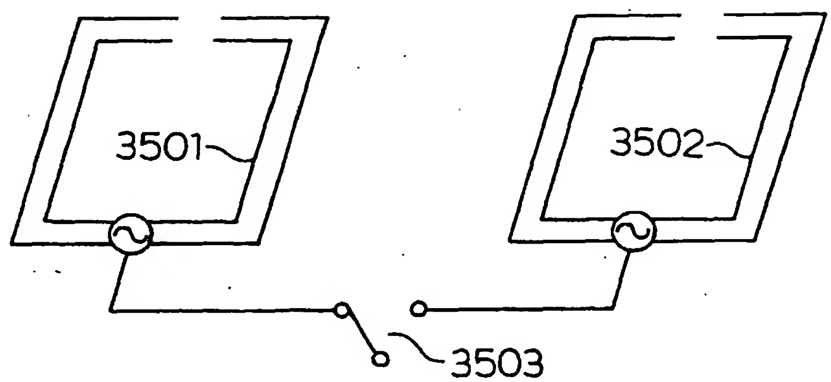


Fig. 35



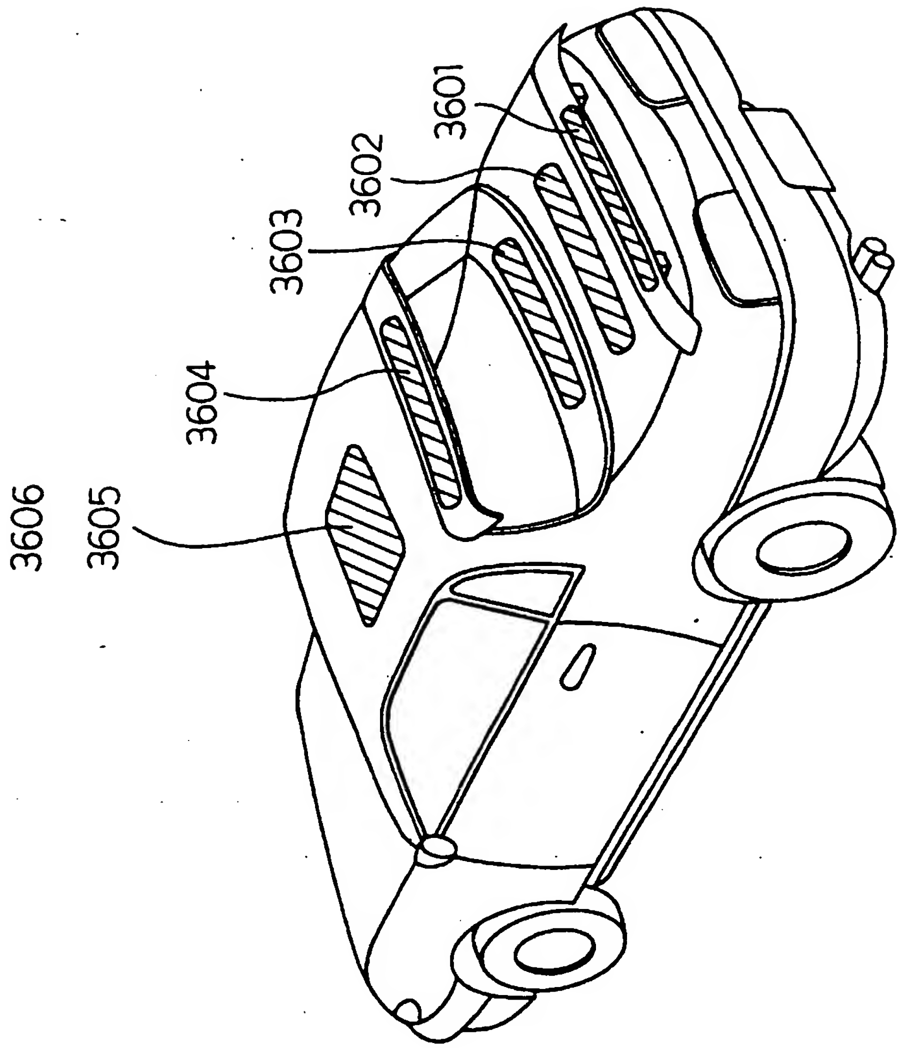


Fig. 36

Fig. 37 (a)

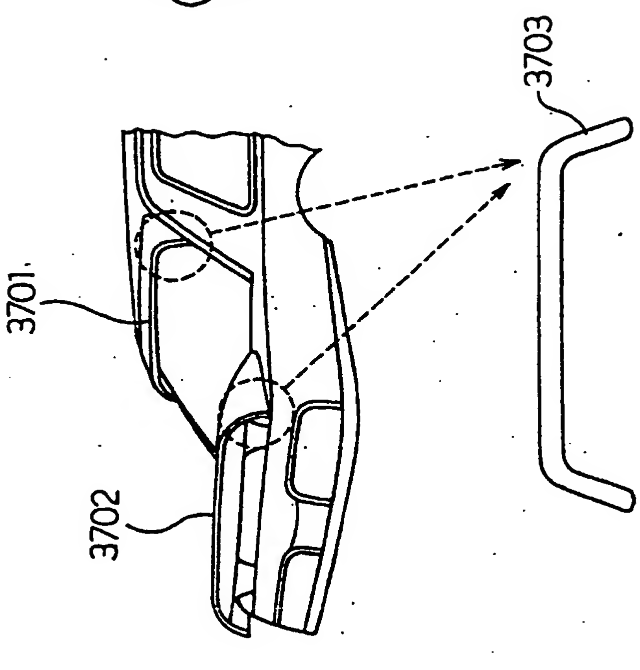
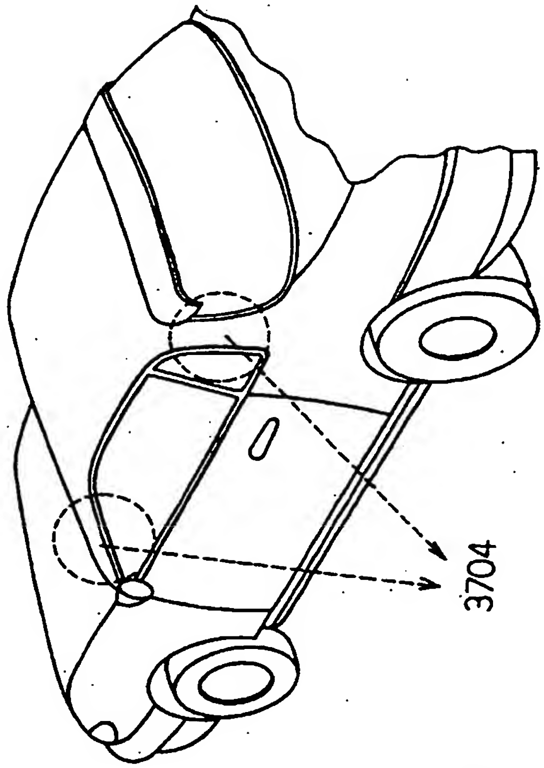


Fig. 37 (b)



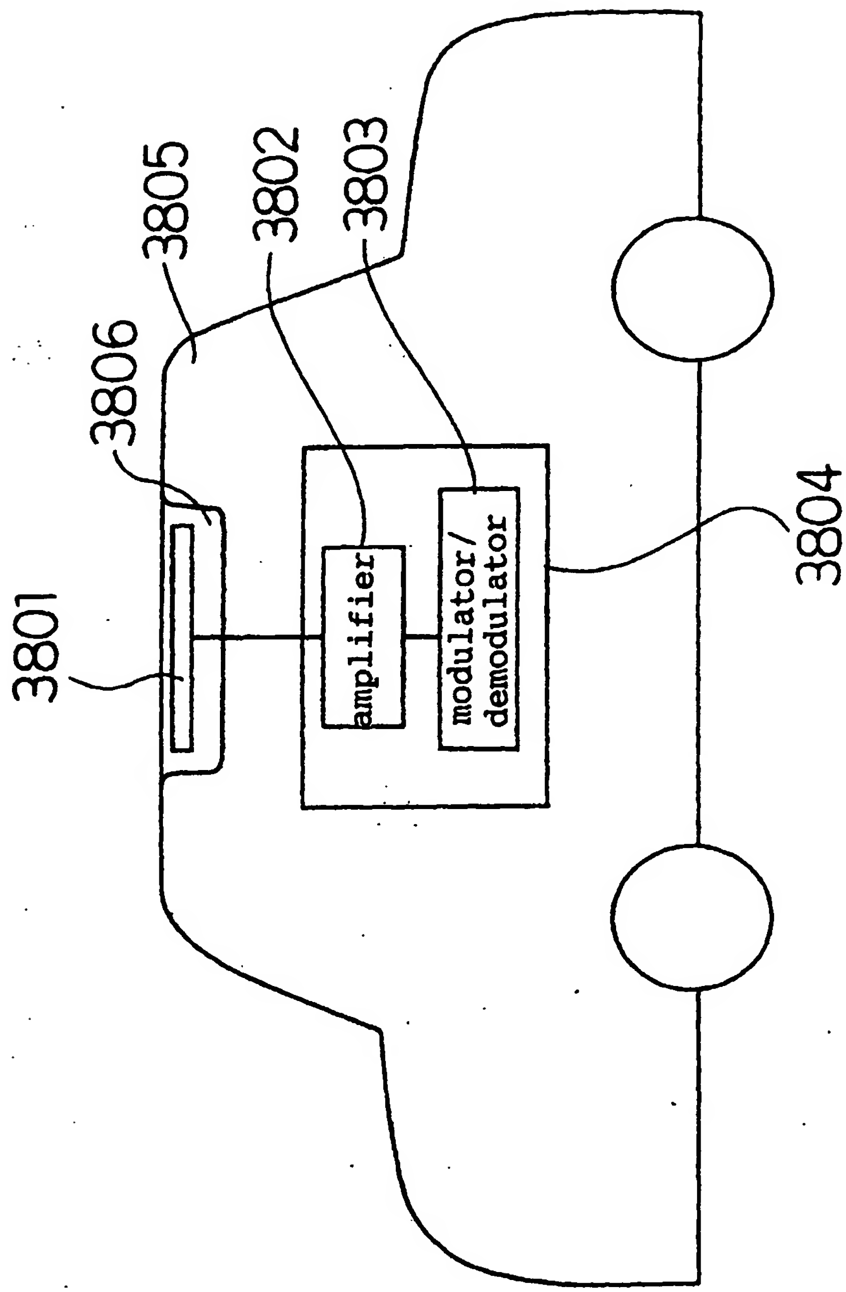

3805
3802
3803
3806
3801
amplifier
modulator/
demodulator
3804

Fig. 38

Fig. 39 (a)

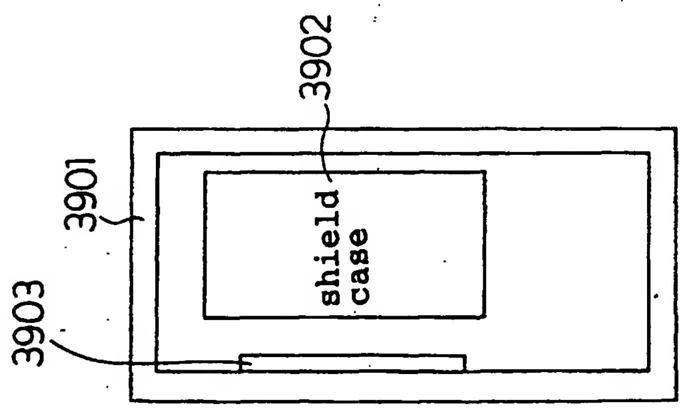


Fig. 39 (b)

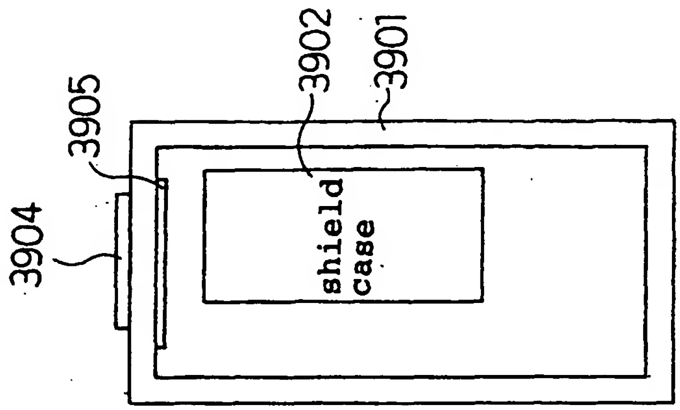


Fig. 40

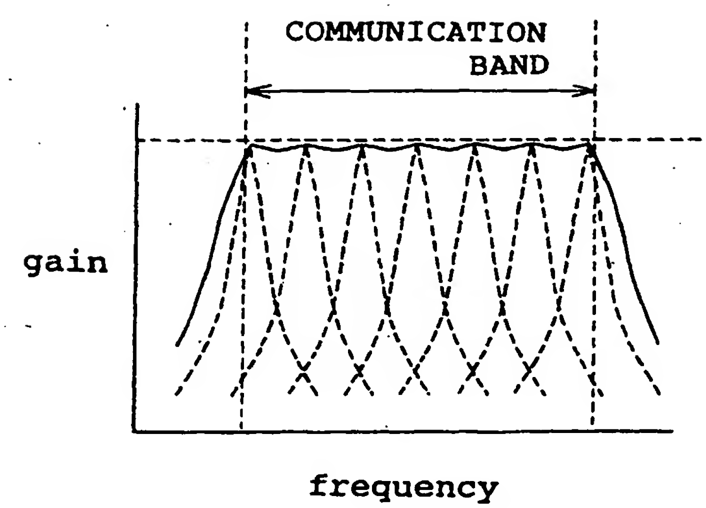


Fig. 41

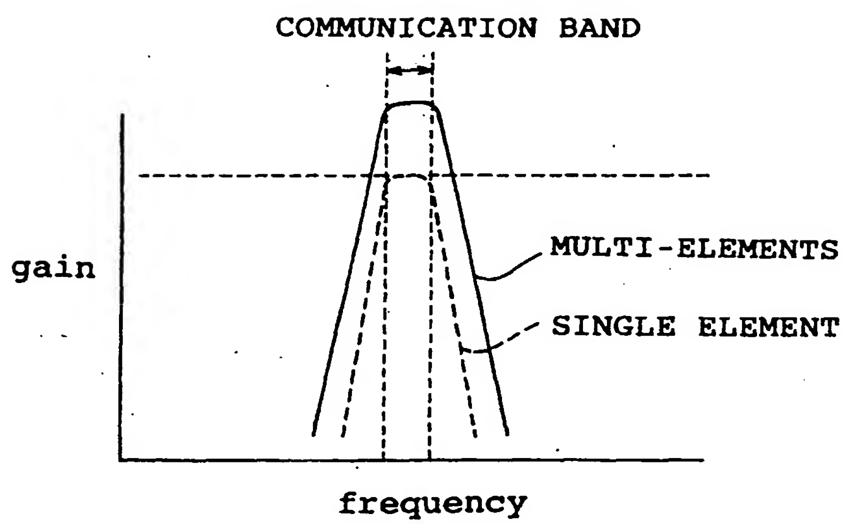

COMMUNICATION BAND
gain
MULTI-ELEMENTS
SINGLE ELEMENT
frequency

Fig. 42(a)

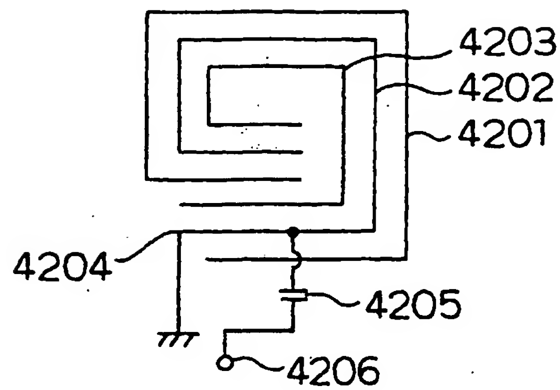


Fig. 42(b)

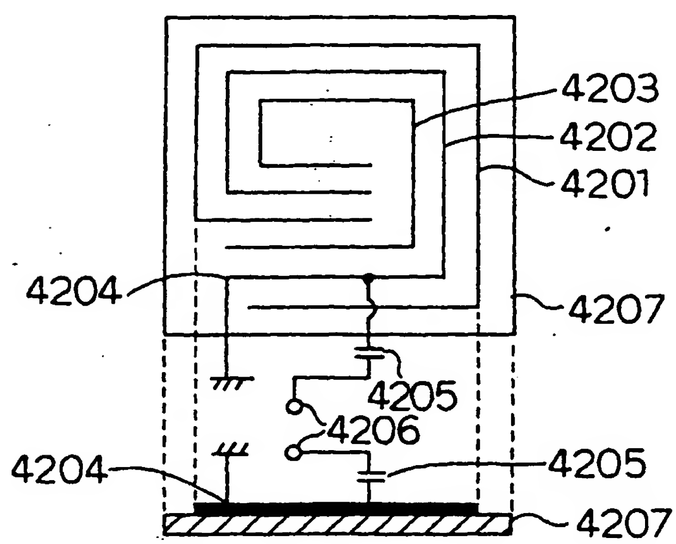


Fig. 43(a)

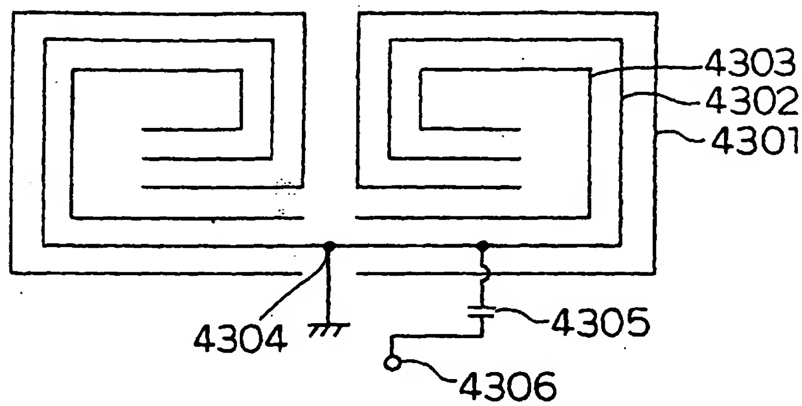


Fig. 43(b)

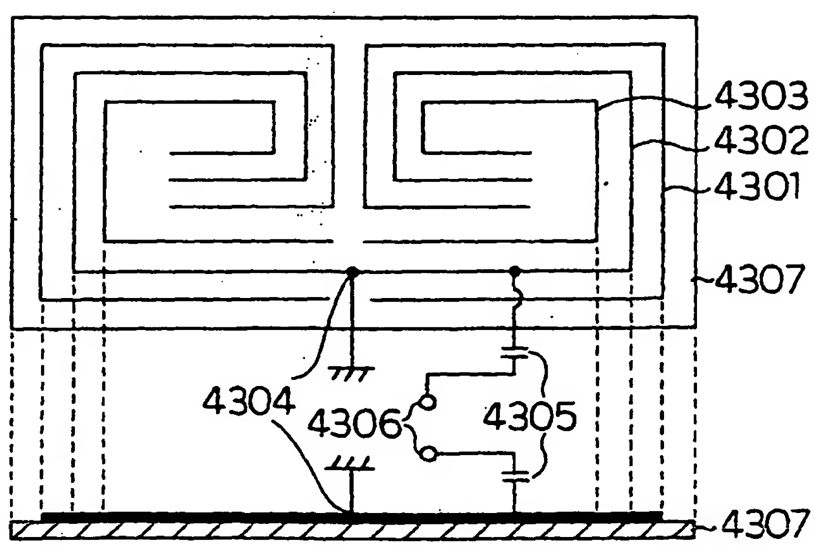


Fig. 44 (a)

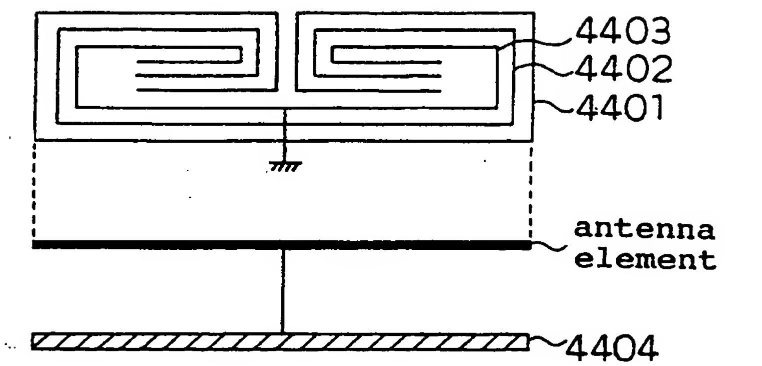


Fig. 44 (b)

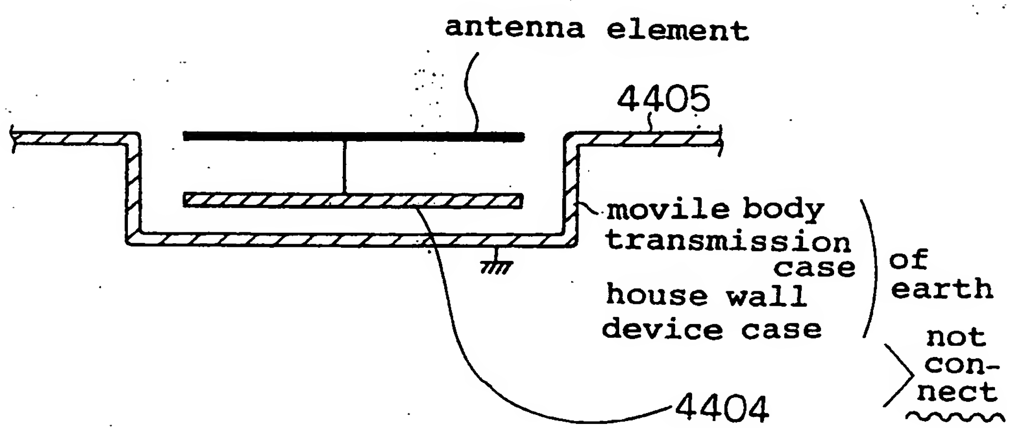


Fig. 45 (a)

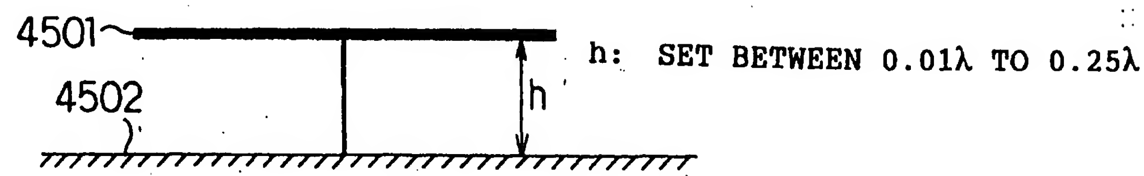


Fig. 45 (b)

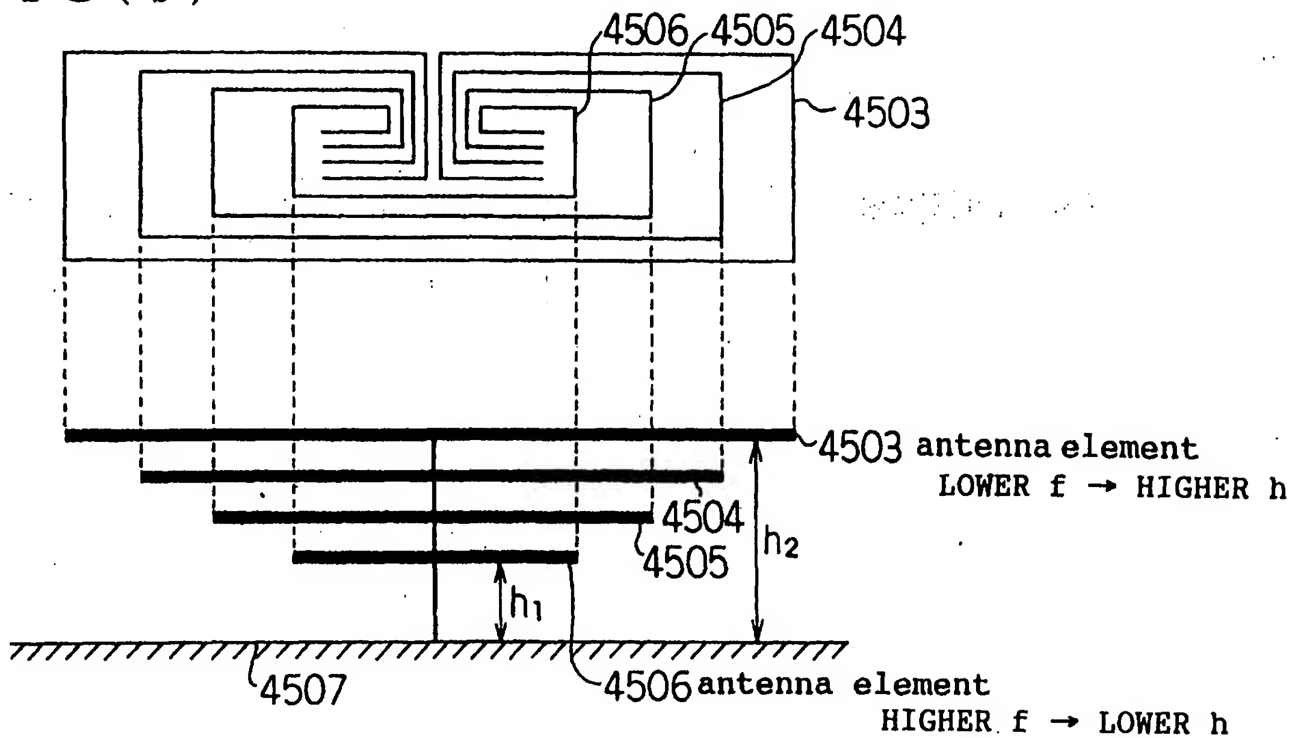


Fig. 46

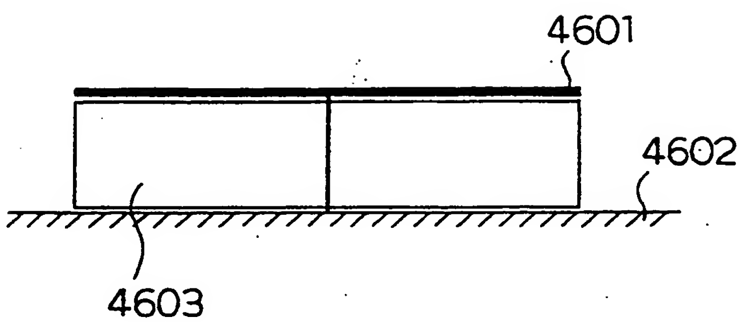


Fig. 47

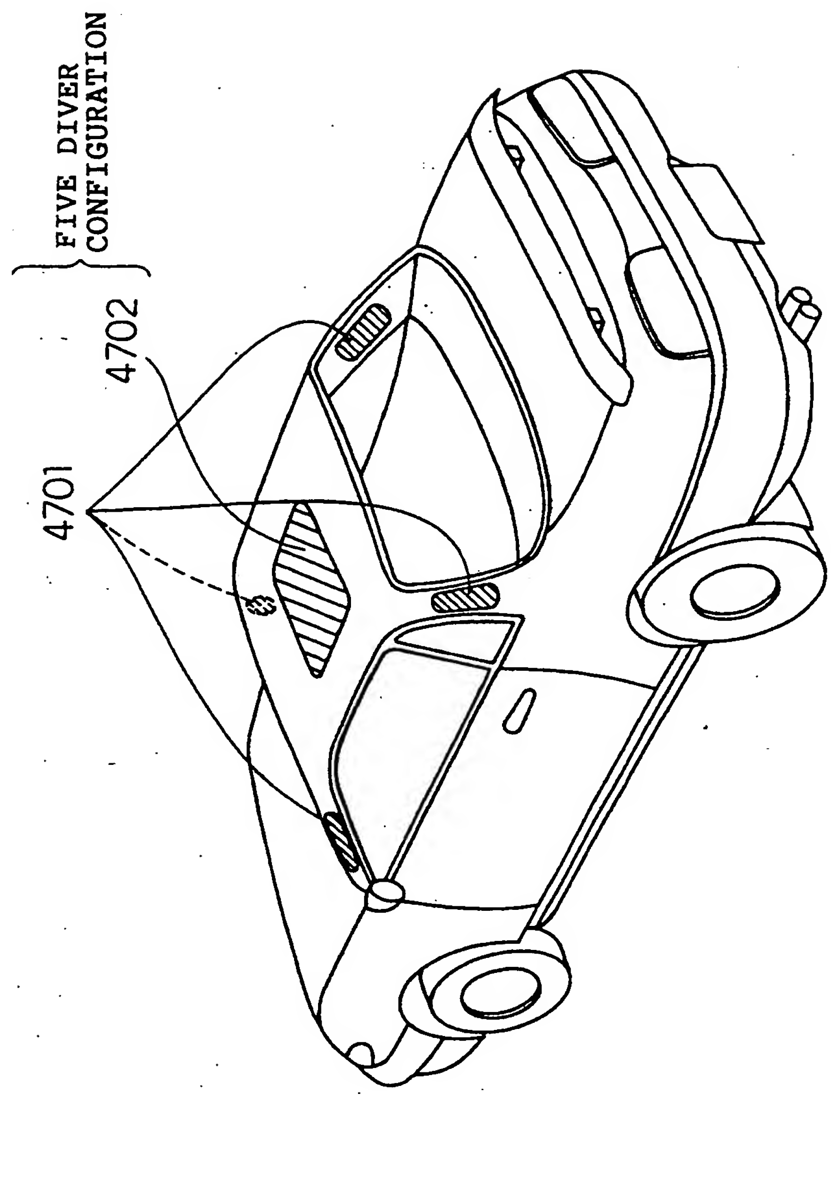


Fig. 48

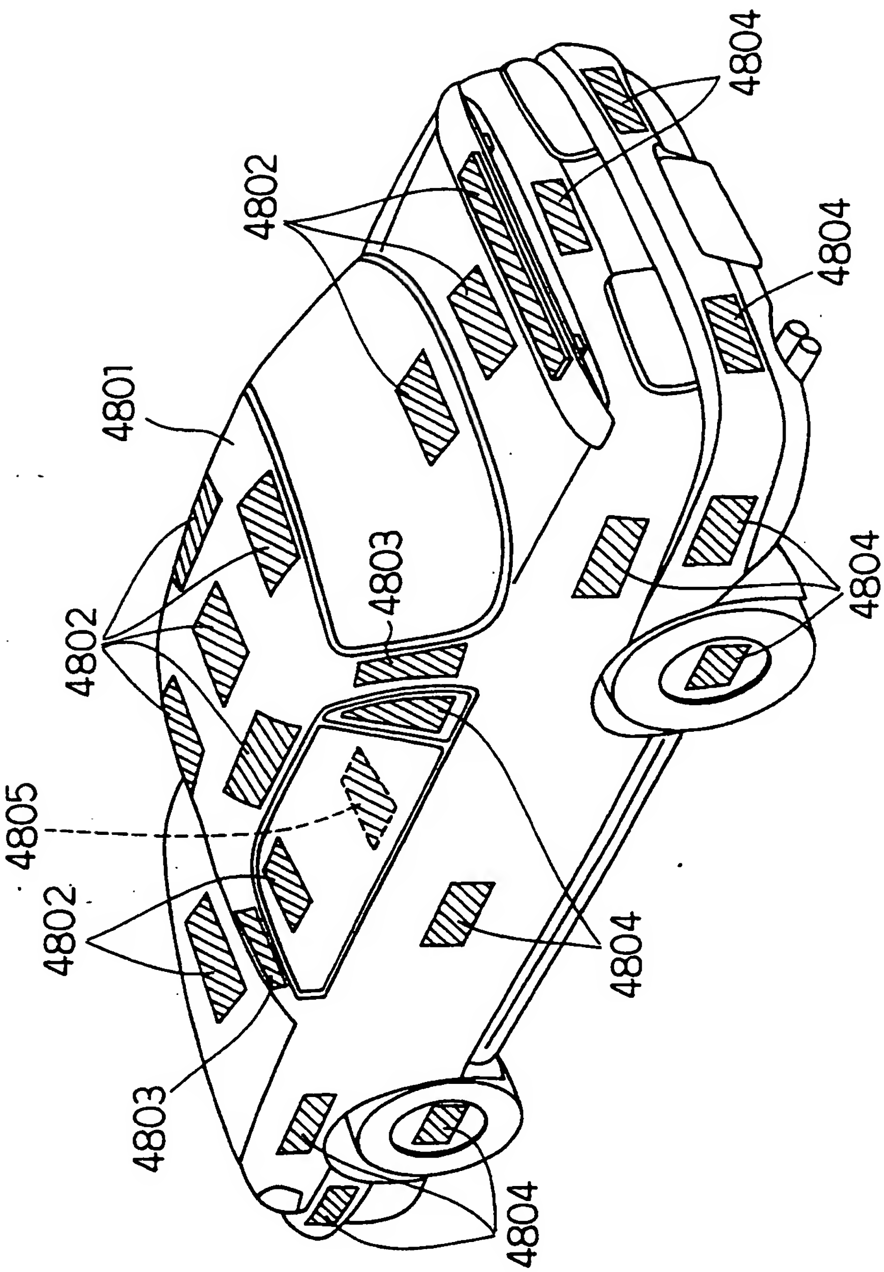


Fig. 49 (a)

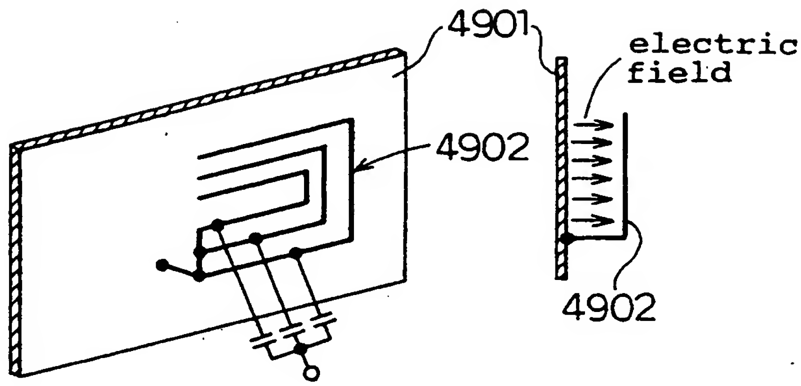


Fig. 49 (b)

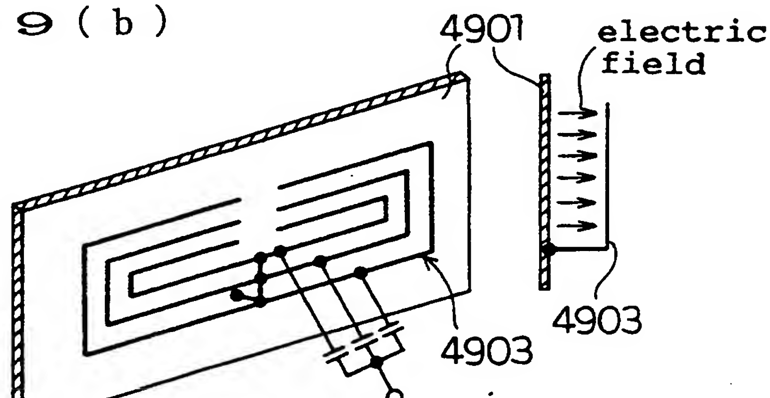


Fig. 50 (a)

Fig. 50 (b)

Fig. 50 (c)

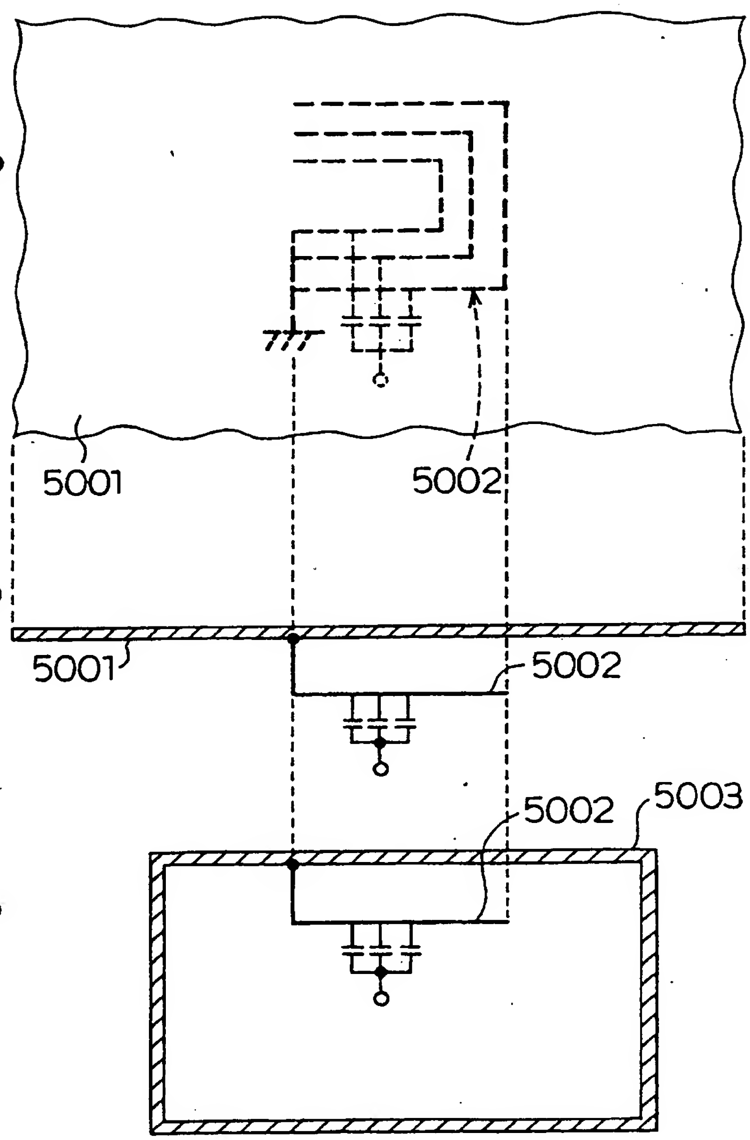
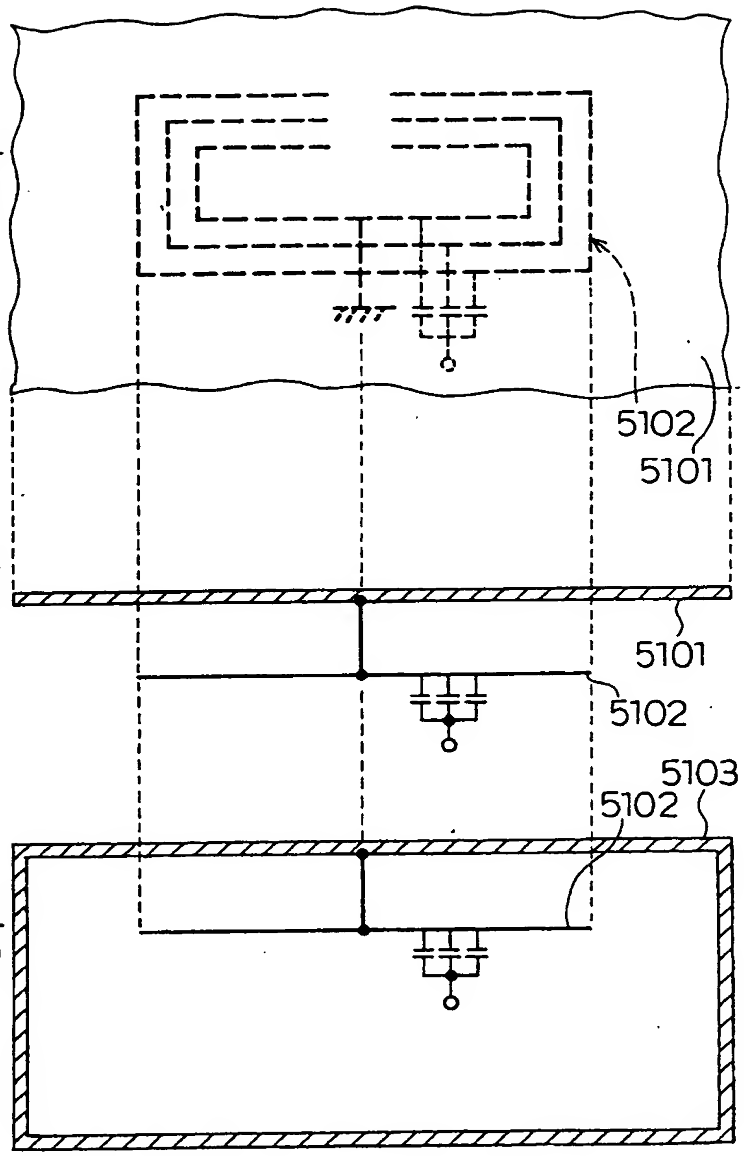


Fig. 51
(a)

Fig. 51
(b)

Fig. 51
(c)



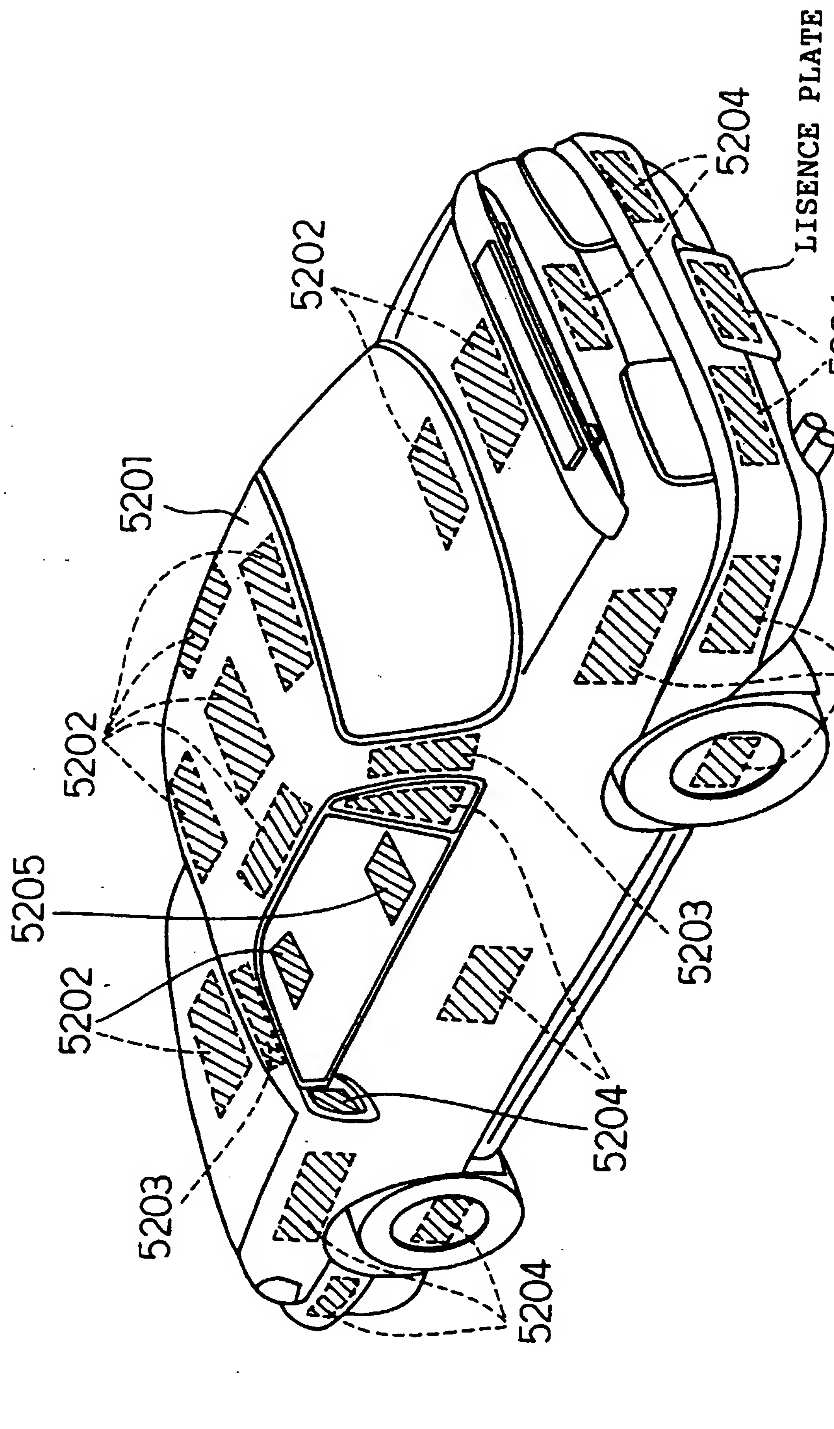

LISENCE PLATE
5204
5202
5204
5201
5204
5202
5205
5203
5202
5204
5203
5204

Fig. 52

Fig. 53

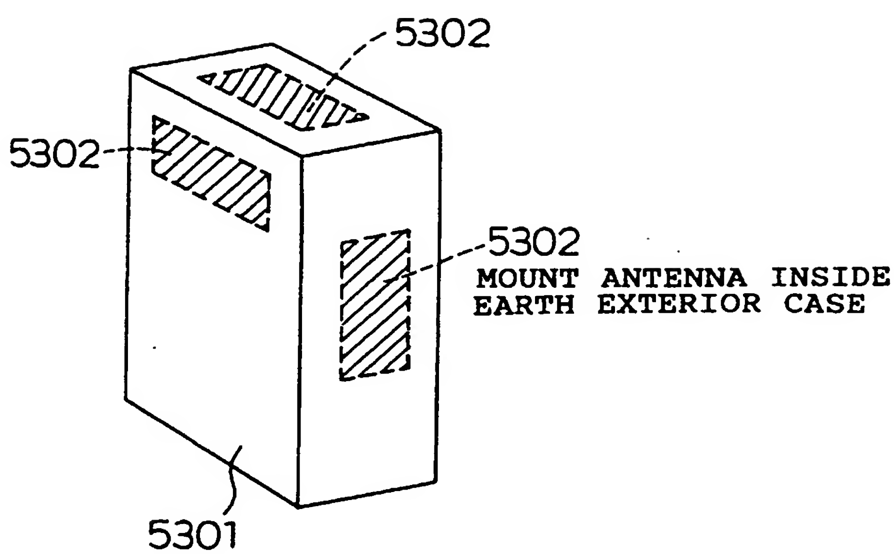

5302
5302
5302
MOUNT ANTENNA INSIDE
EARTH EXTERIOR CASE
5301

Fig. 54

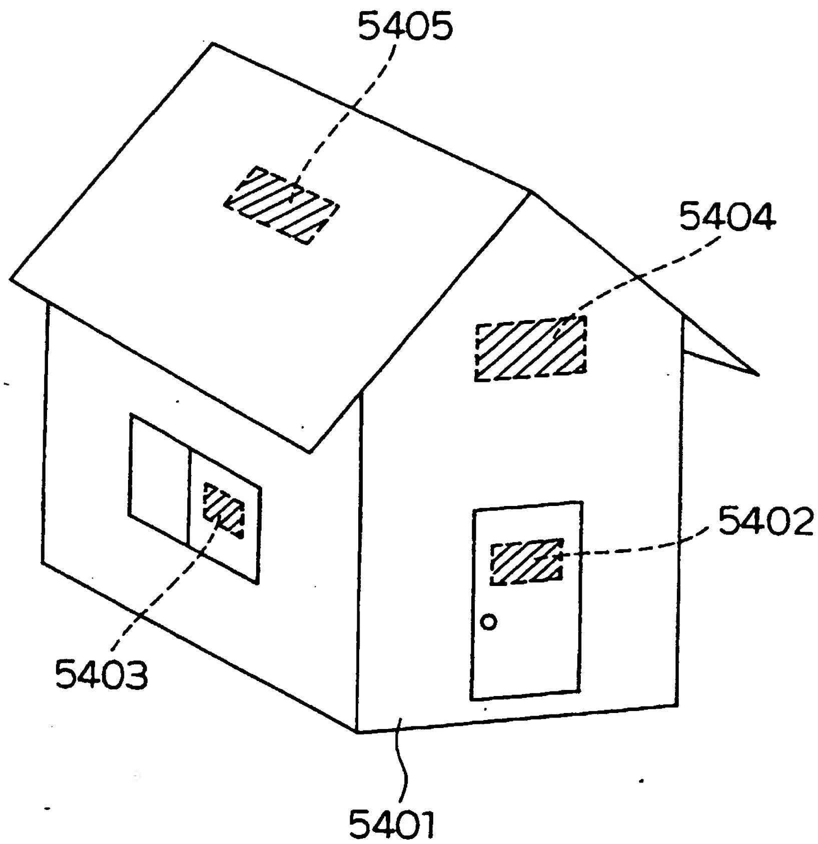


Fig. 55 (a)

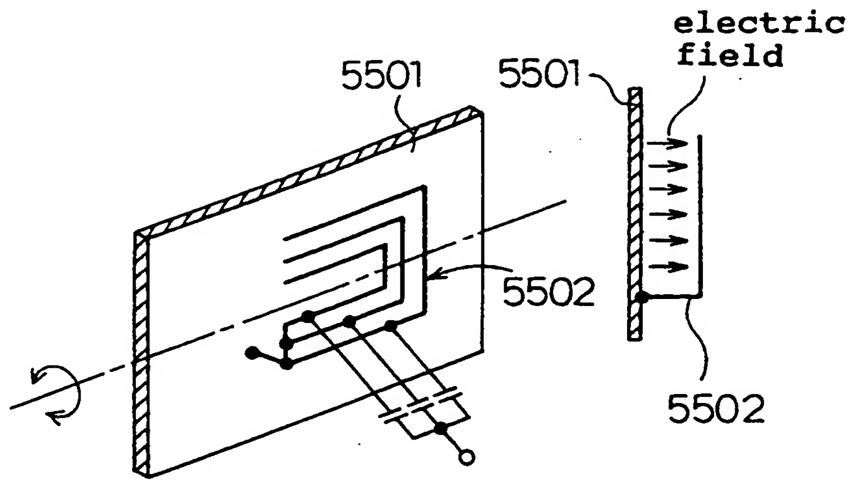


Fig. 55 (b)

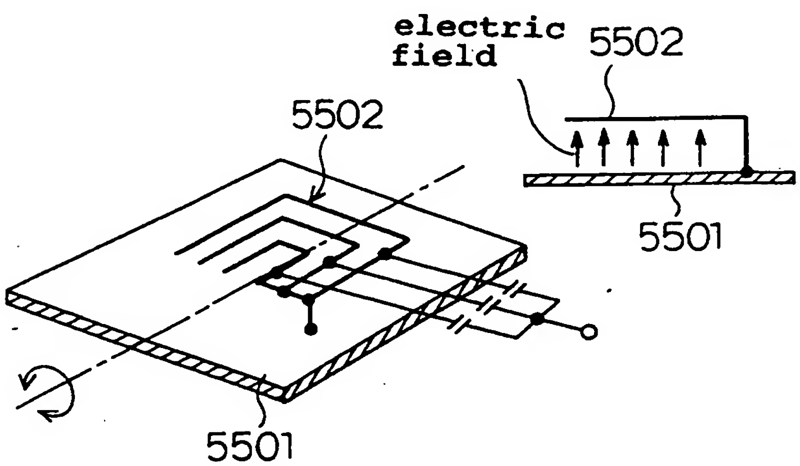


Fig. 56 (a)

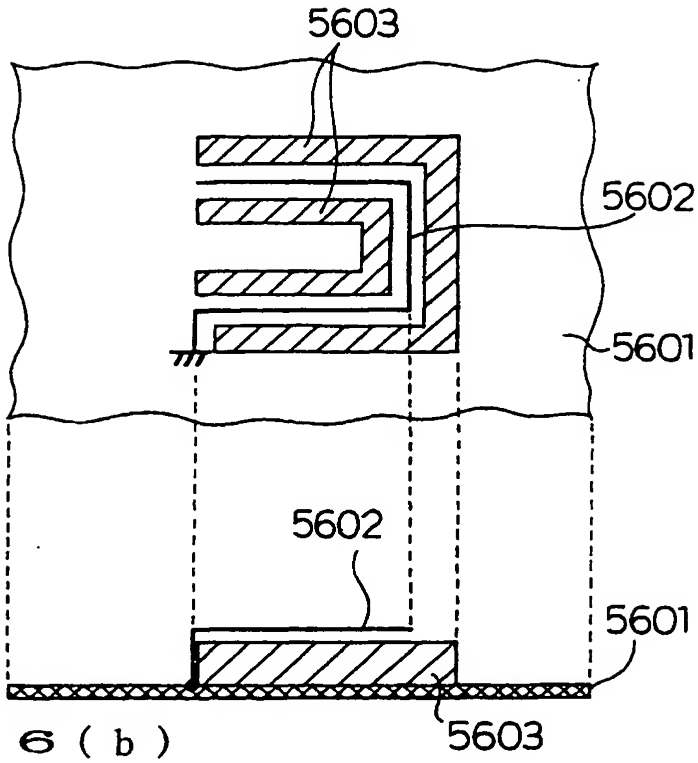


Fig. 56 (b)

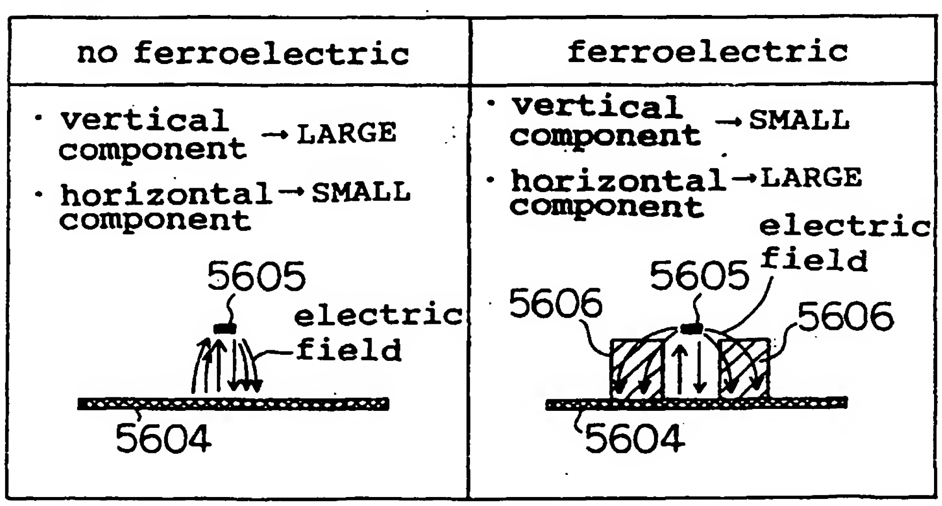


Fig. 57 (a)

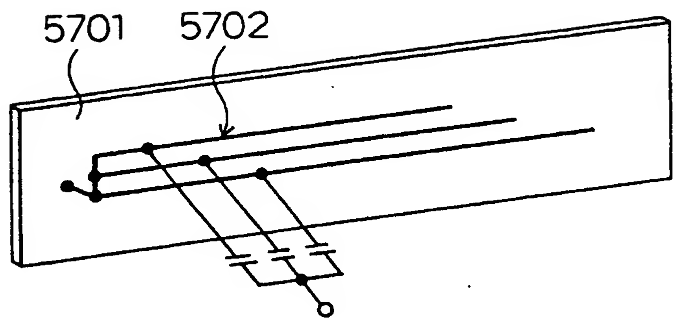


Fig. 57 (b)

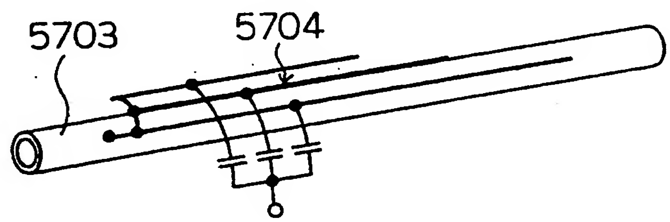


Fig. 57 (c)

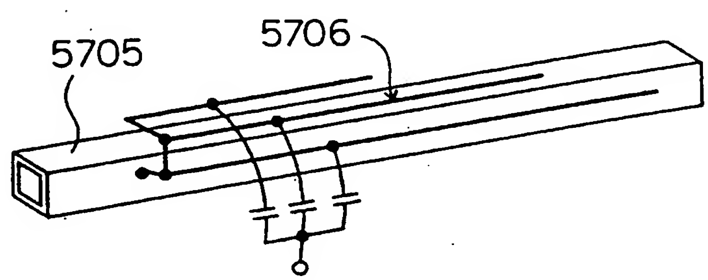


Fig. 58
(a)

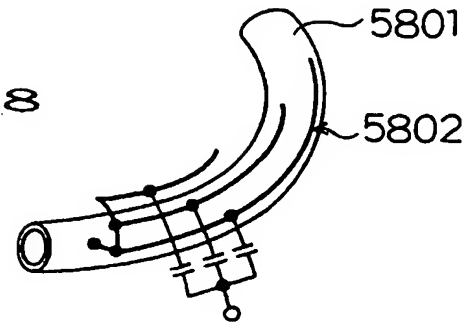


Fig. 58
(b)

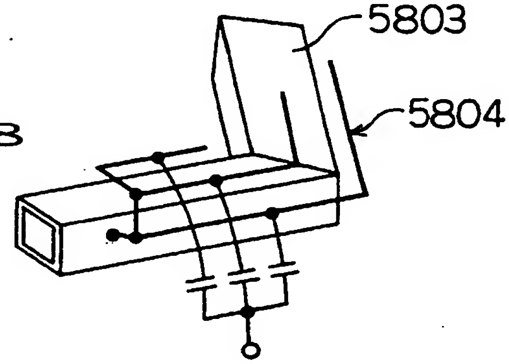


Fig. 58
(c)

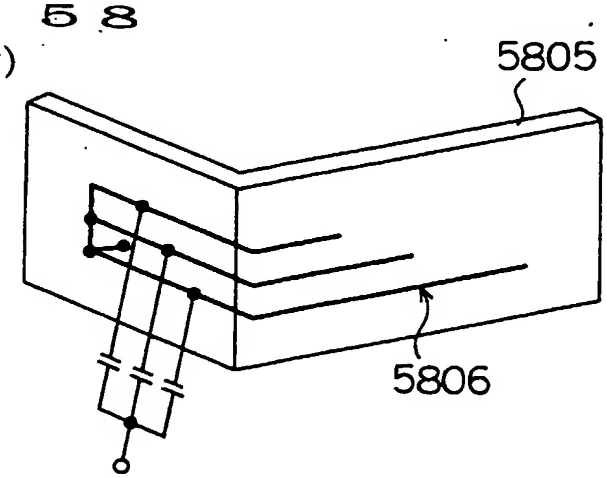


Fig. 59
(a)

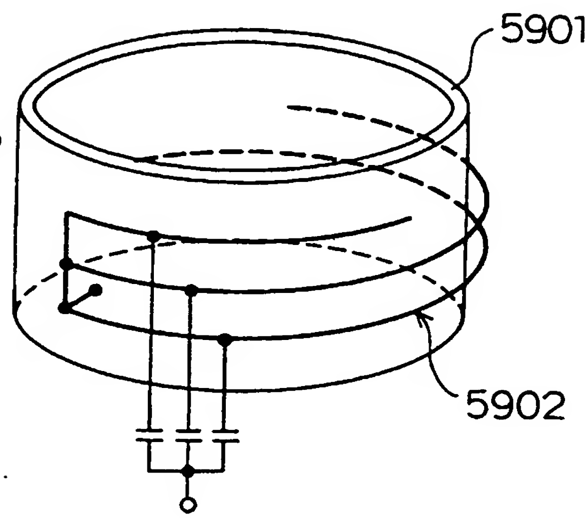


Fig. 59
(b)

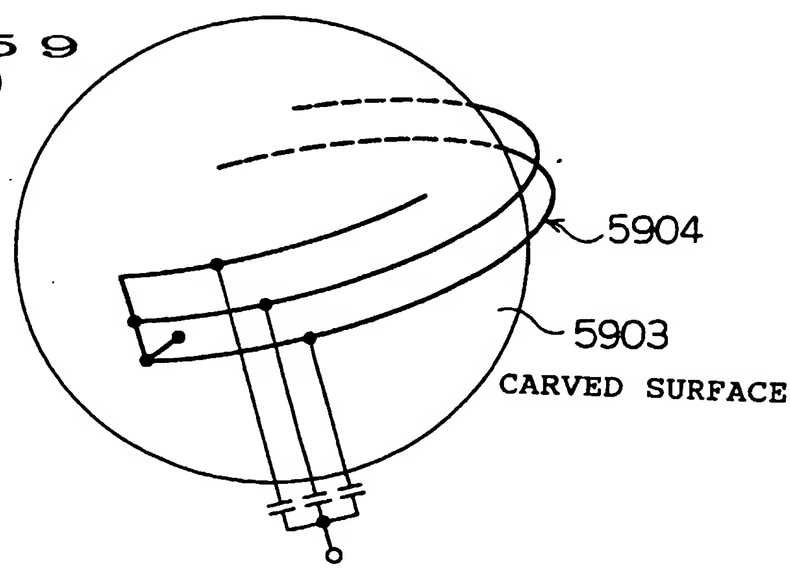


Fig. 60 (a)

Fig. 60 (b)

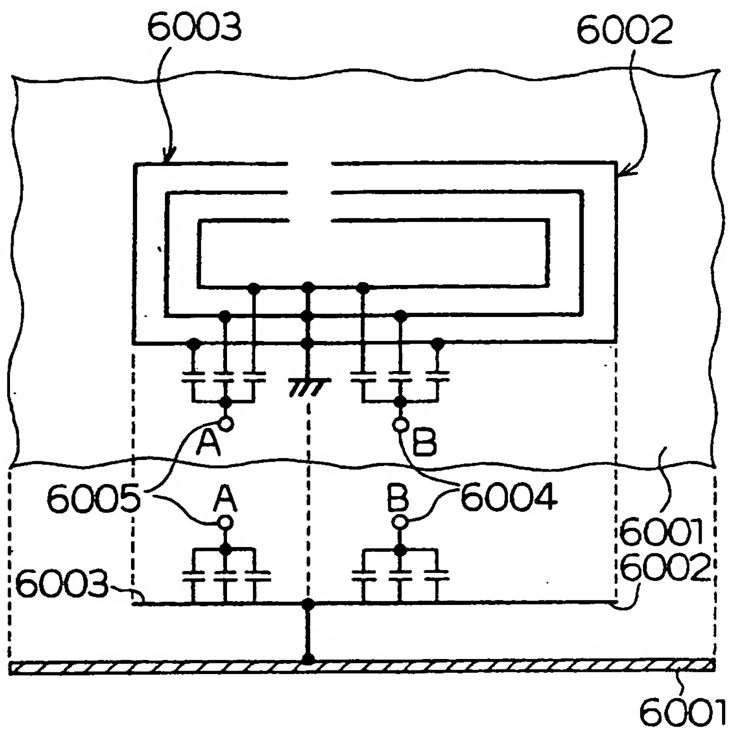


Fig. 60 (c)

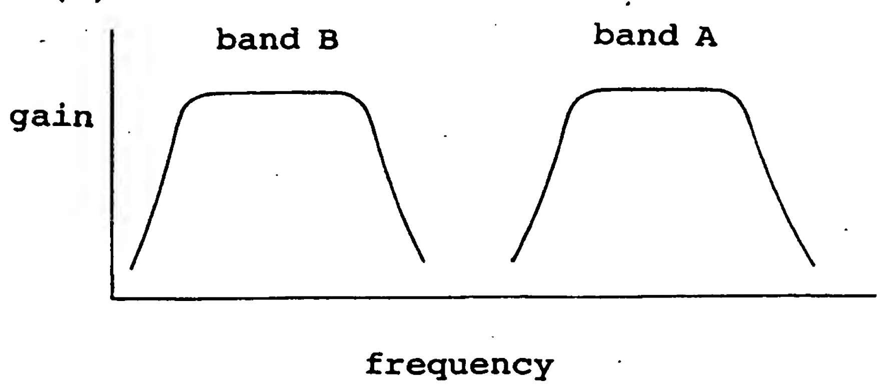


Fig. 61 (a)

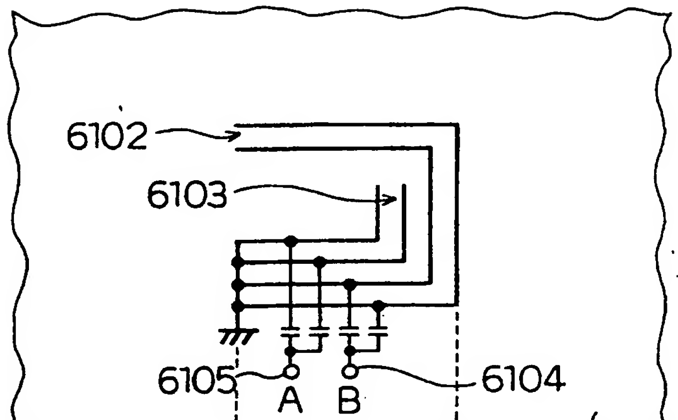


Fig. 61 (b)

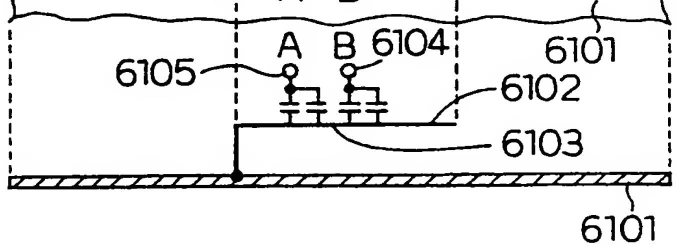


Fig. 61 (c)

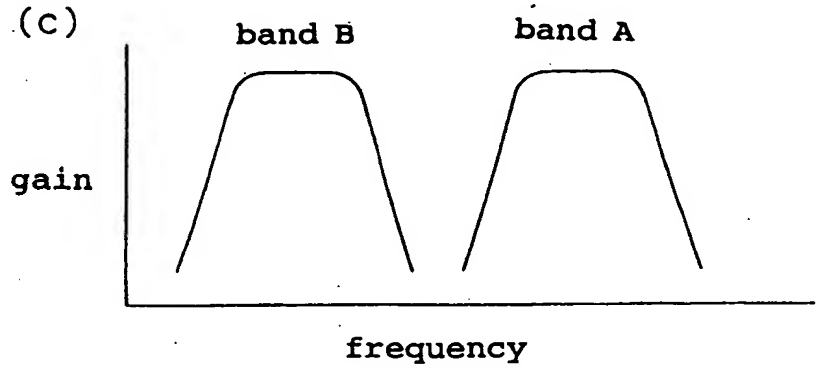


Fig. 62
(a)

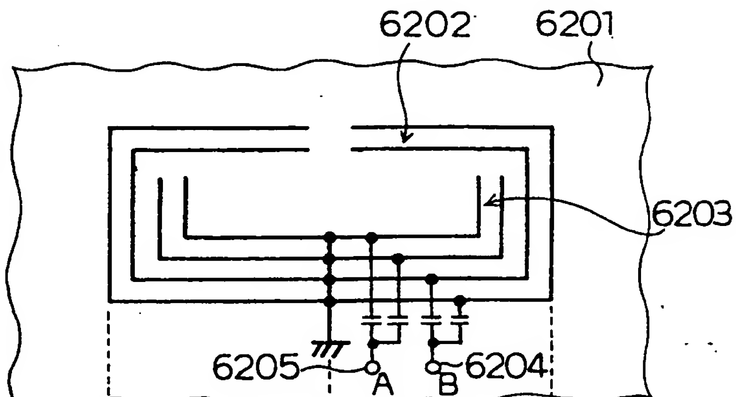


Fig. 62
(b)

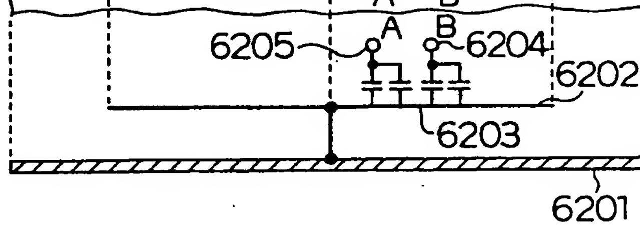
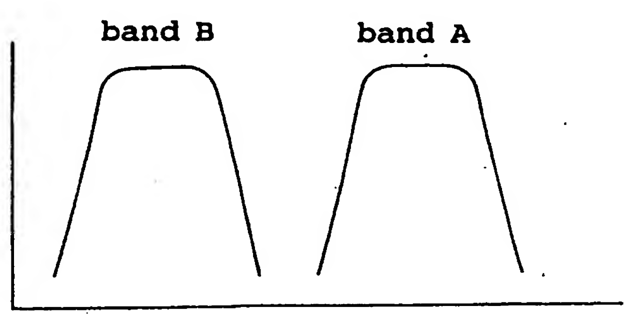


Fig. 62
(c)



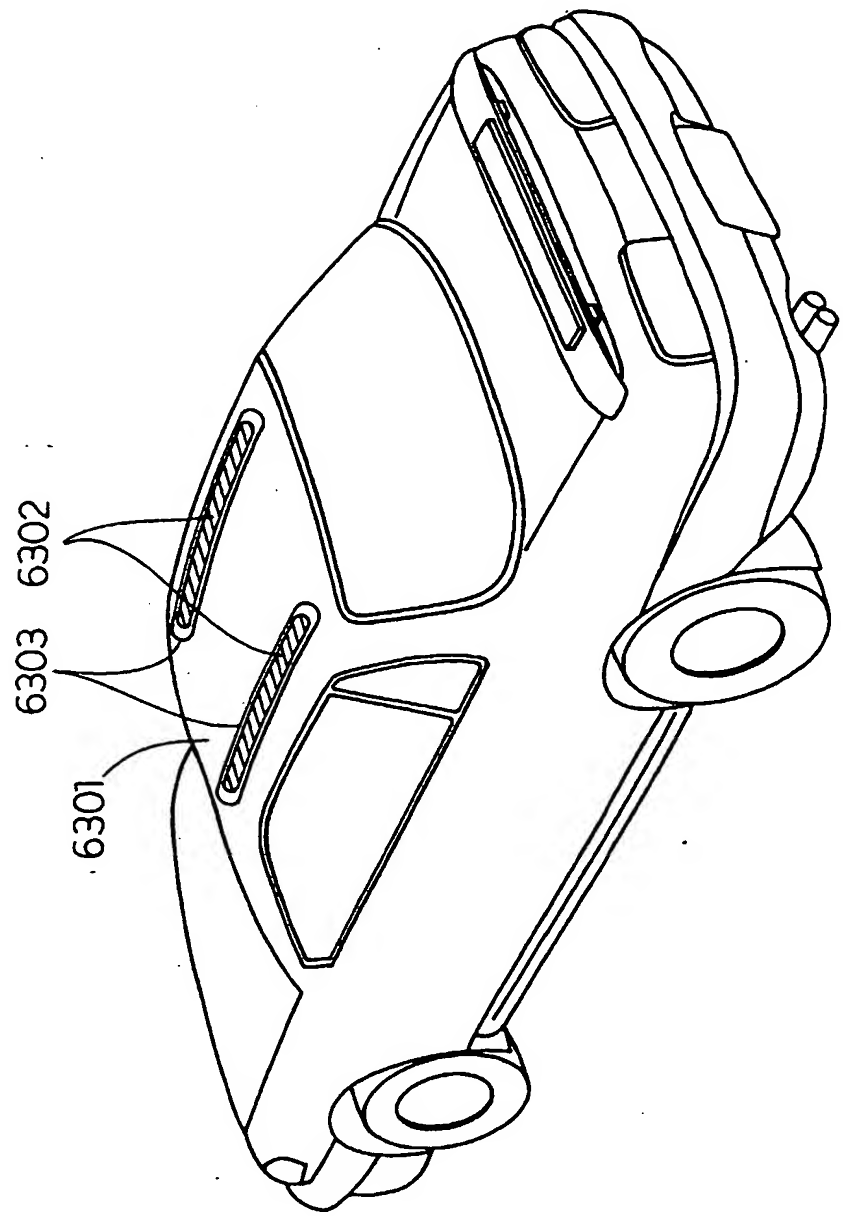


Fig. 63

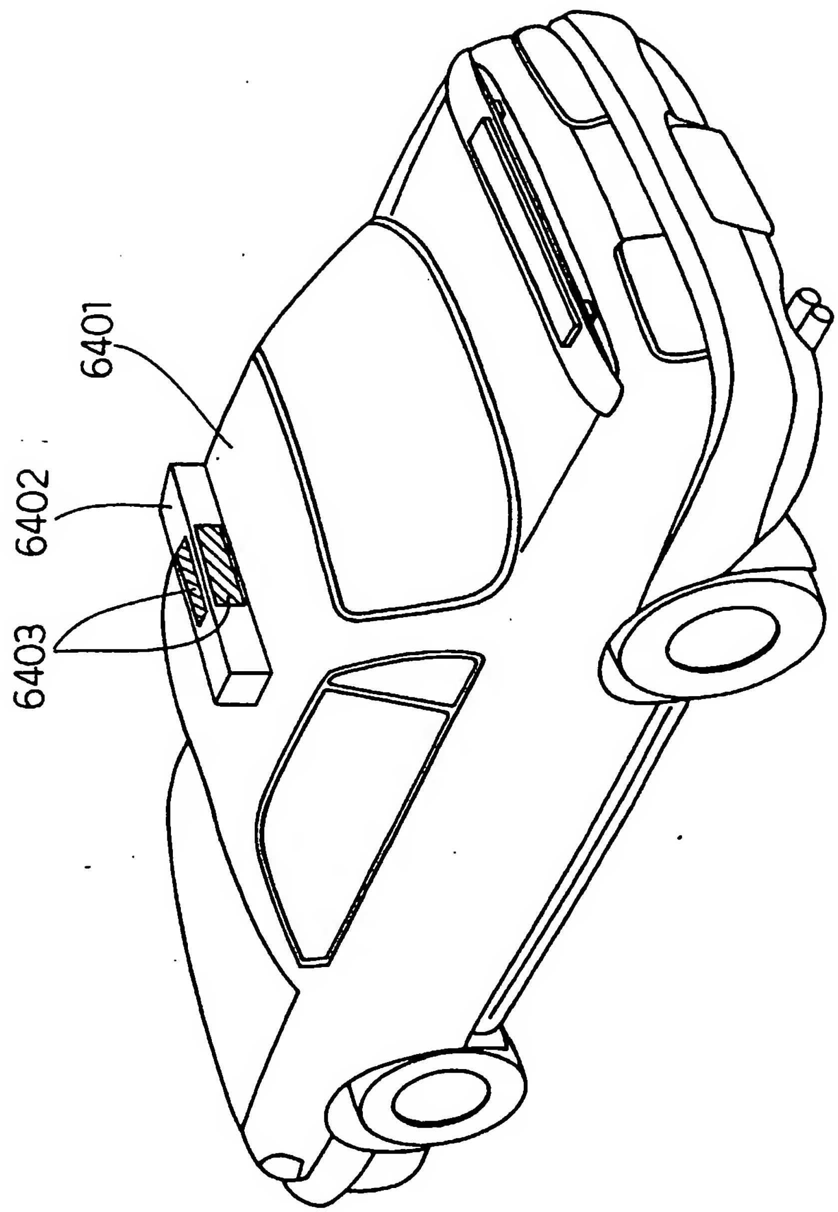


Fig. 64

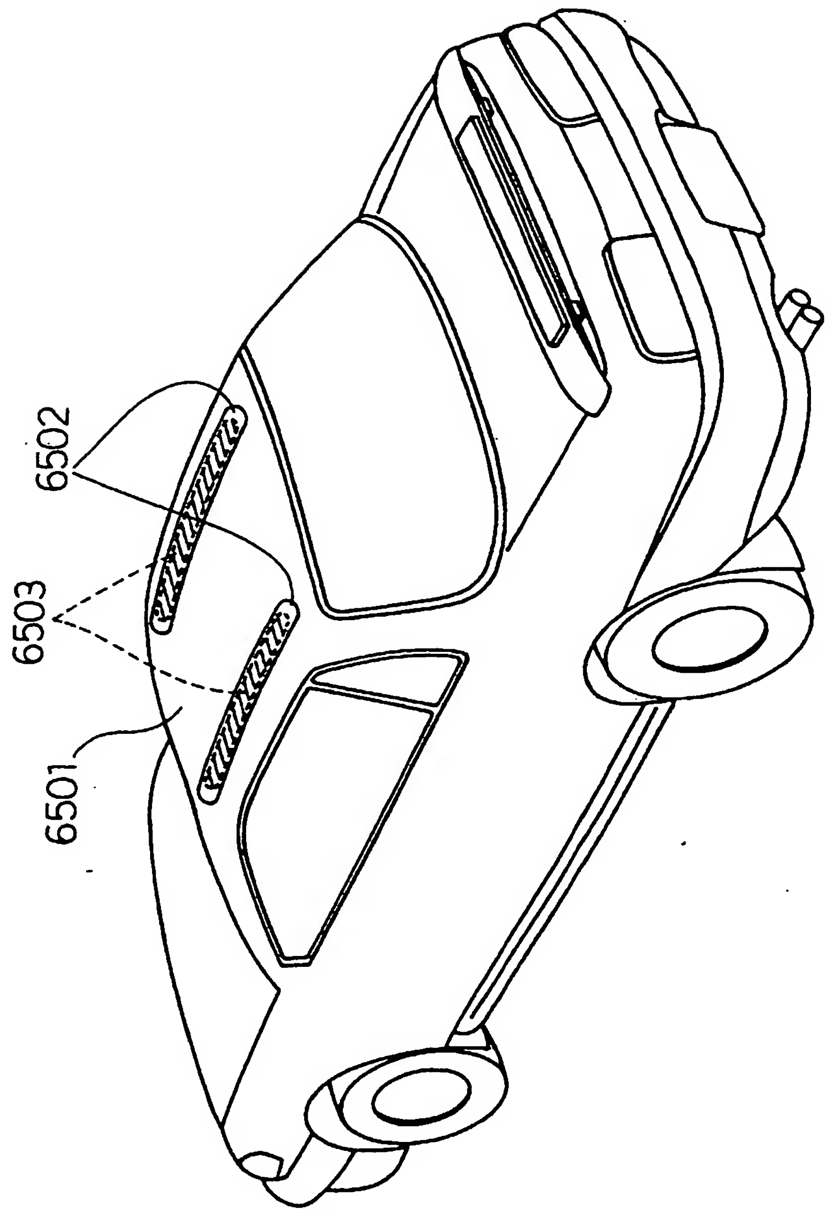


Fig. 65

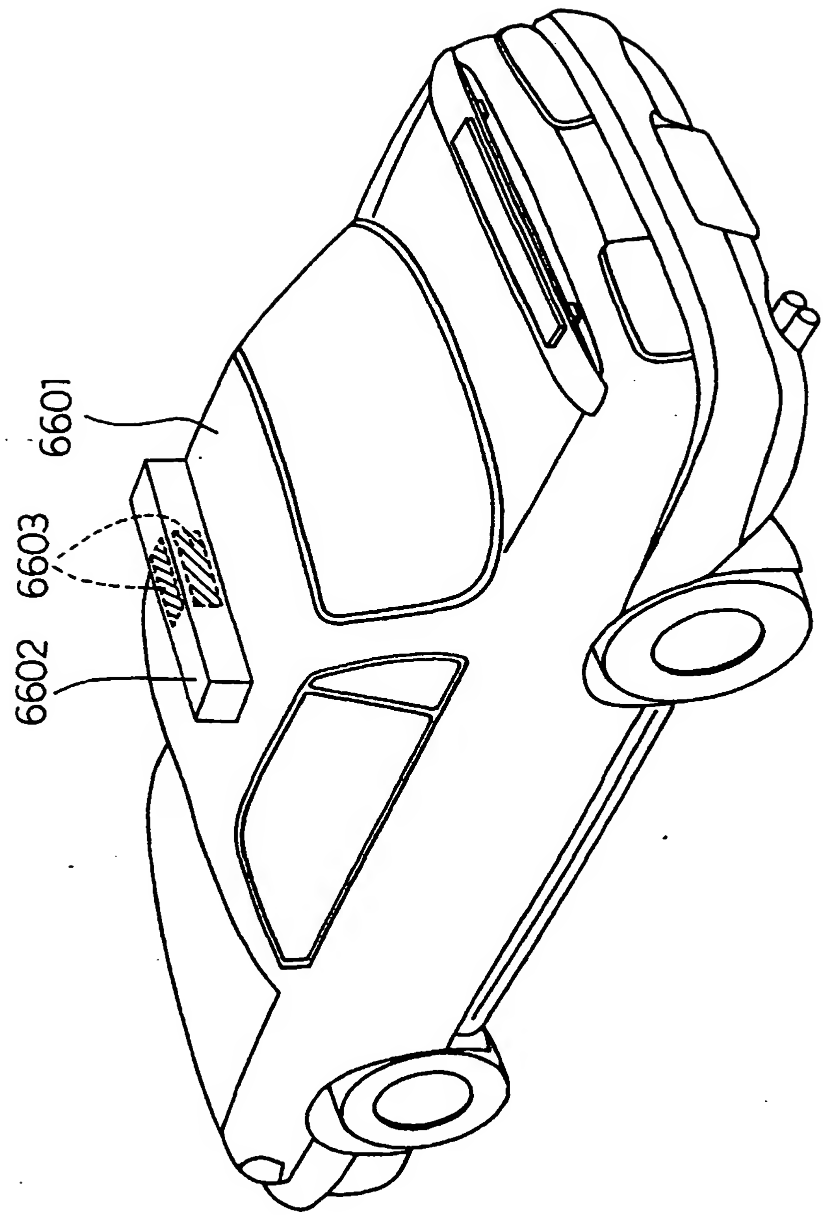


Fig. 66

Fig. 67

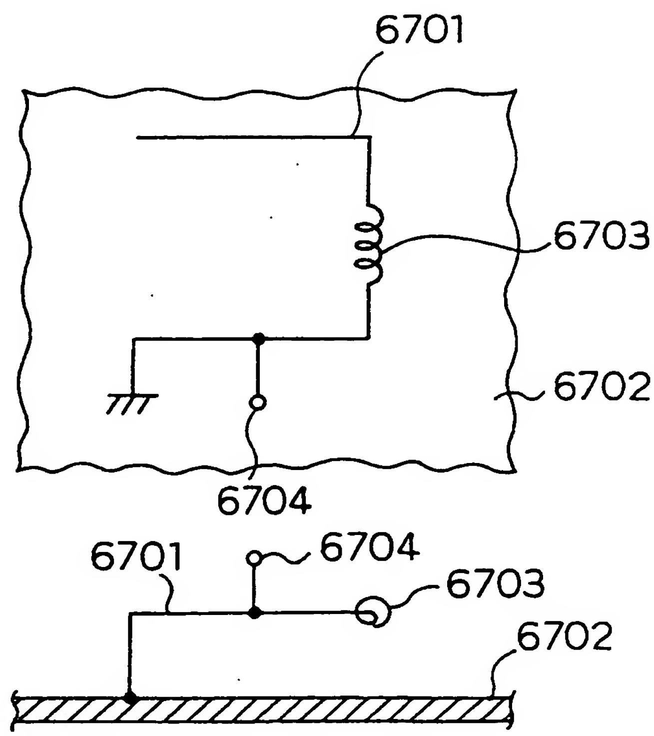


Fig. 68

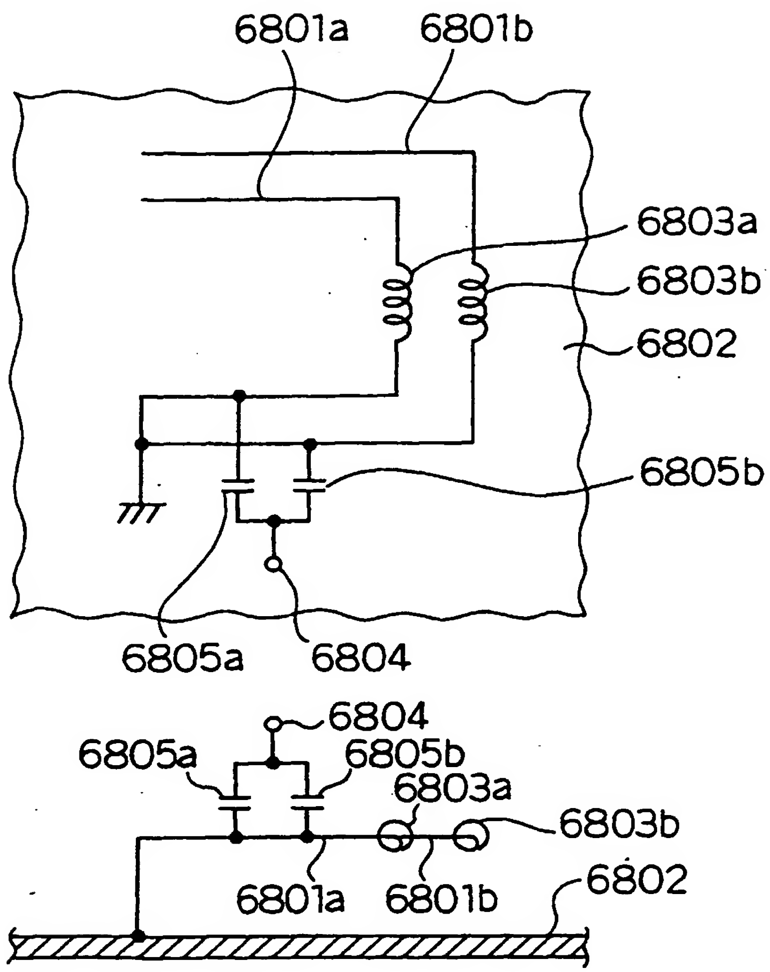

6801a
6801b
6803a
6803b
6802
6805b
6805a
6804
6804
6805a
6805b
6803a
6803b
6801a
6801b
6802

Fig. 69

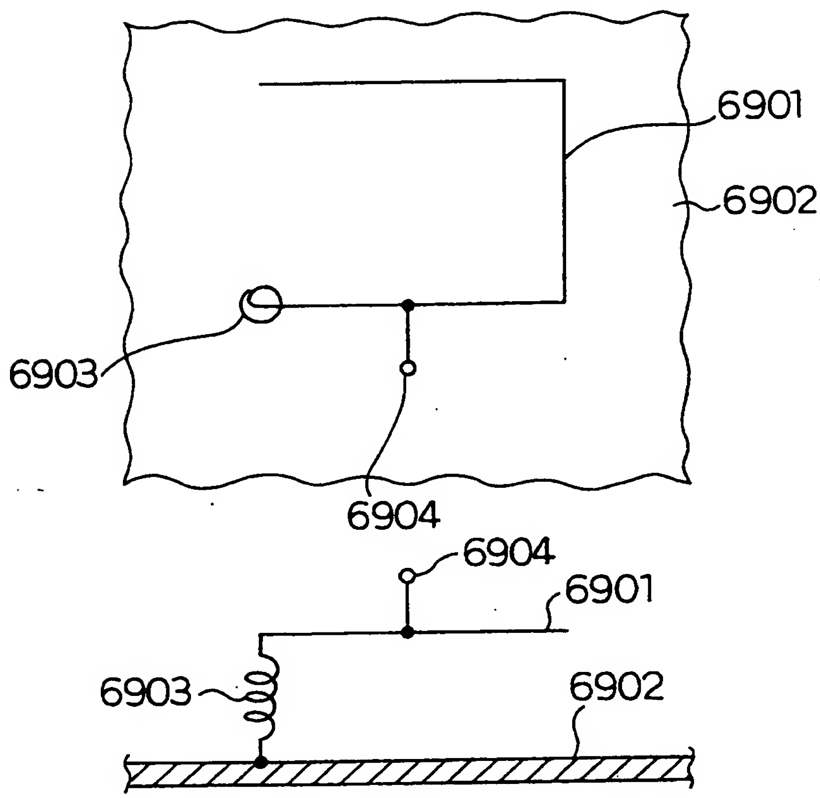


Fig. 70

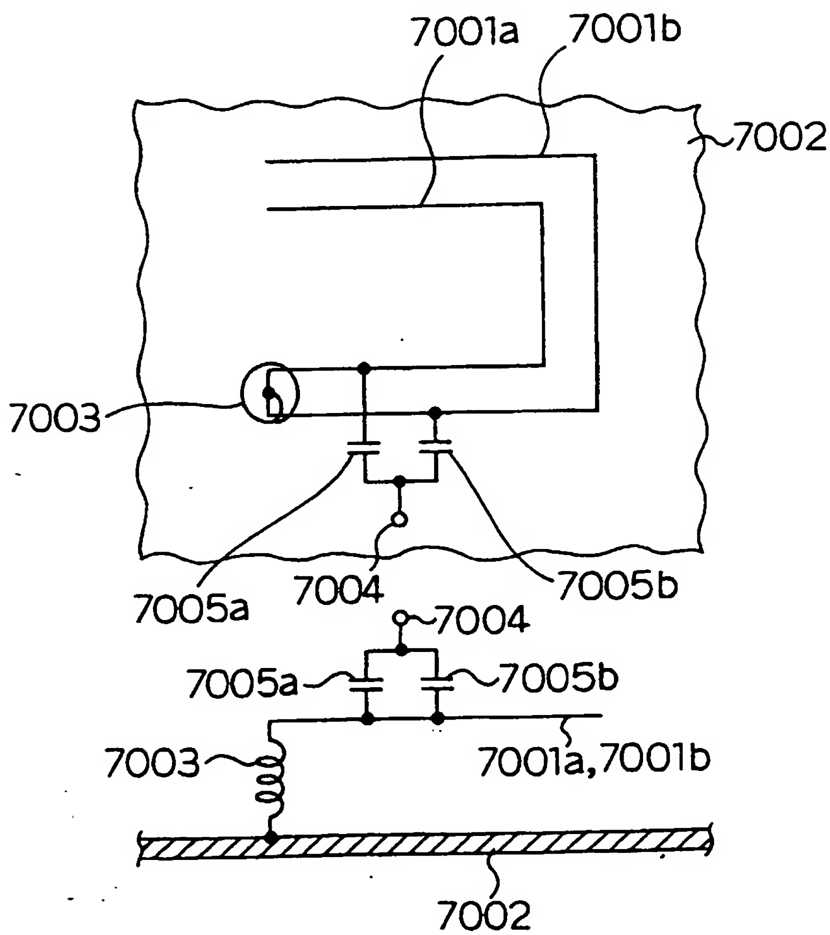

7001a
7001b
7002
7003
7005a
7004
7005b
7004
7005a
7005b
7003
7001a,7001b
7002

Fig. 71

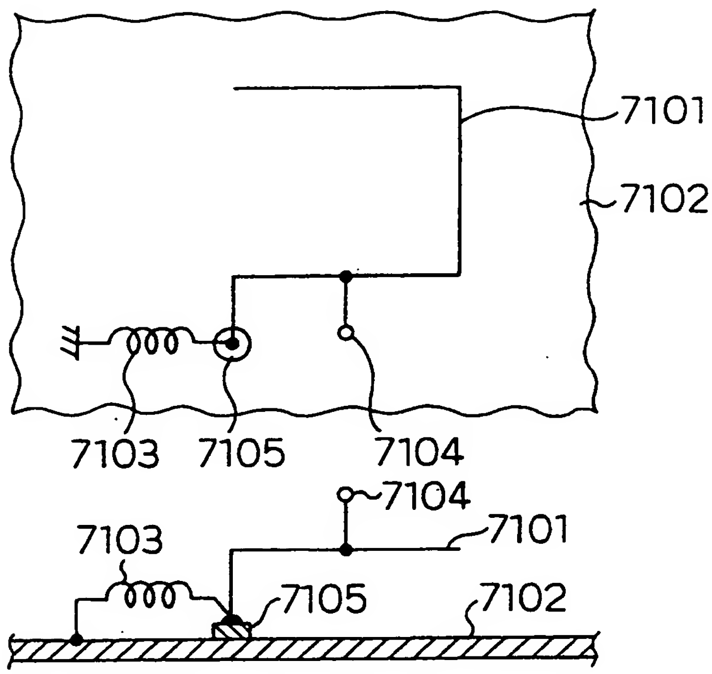


Fig. 72

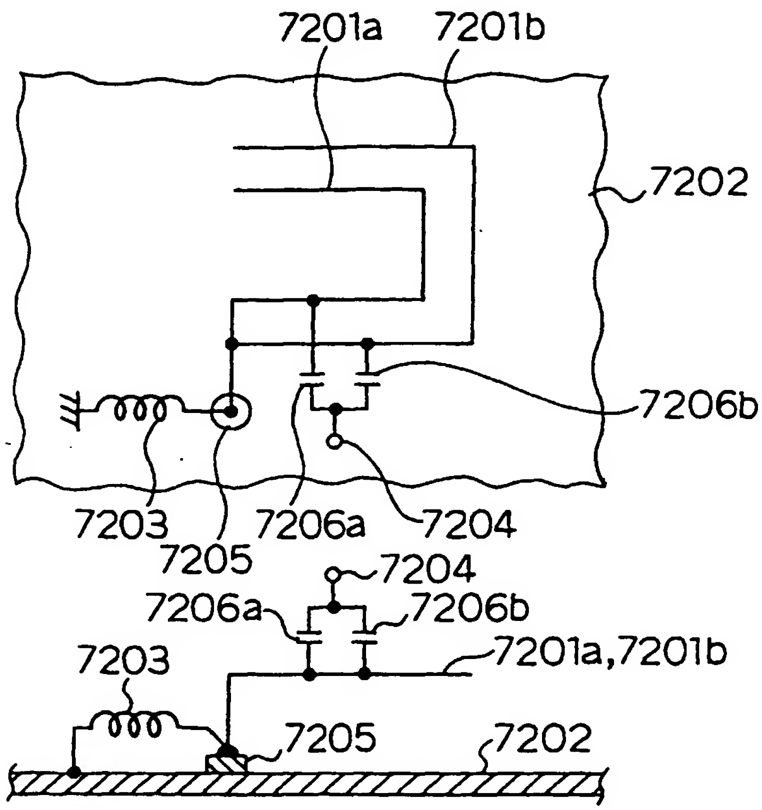

7201a
7201b
7202
7206b
7203
7205
7206a
7204
7204
7206a
7206b
7201a,7201b
7203
7205
7202

Fig. 73

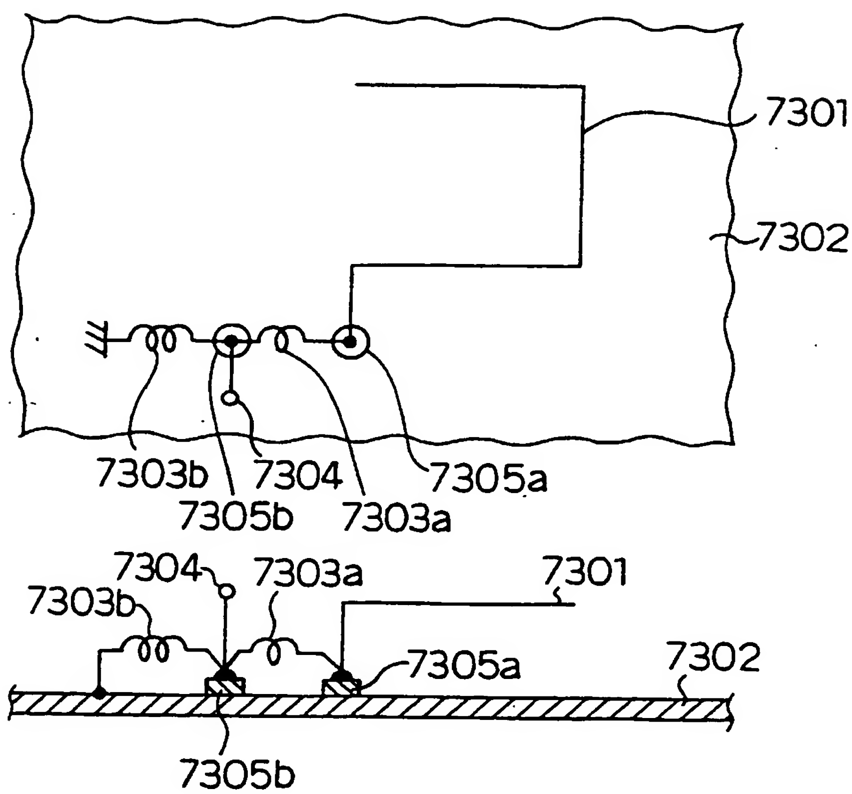

7301
7302
7303b
7304
7305a
7305b
7303a
7304
7303a
7301
7303b
7305a
7302
7305b

Fig. 74

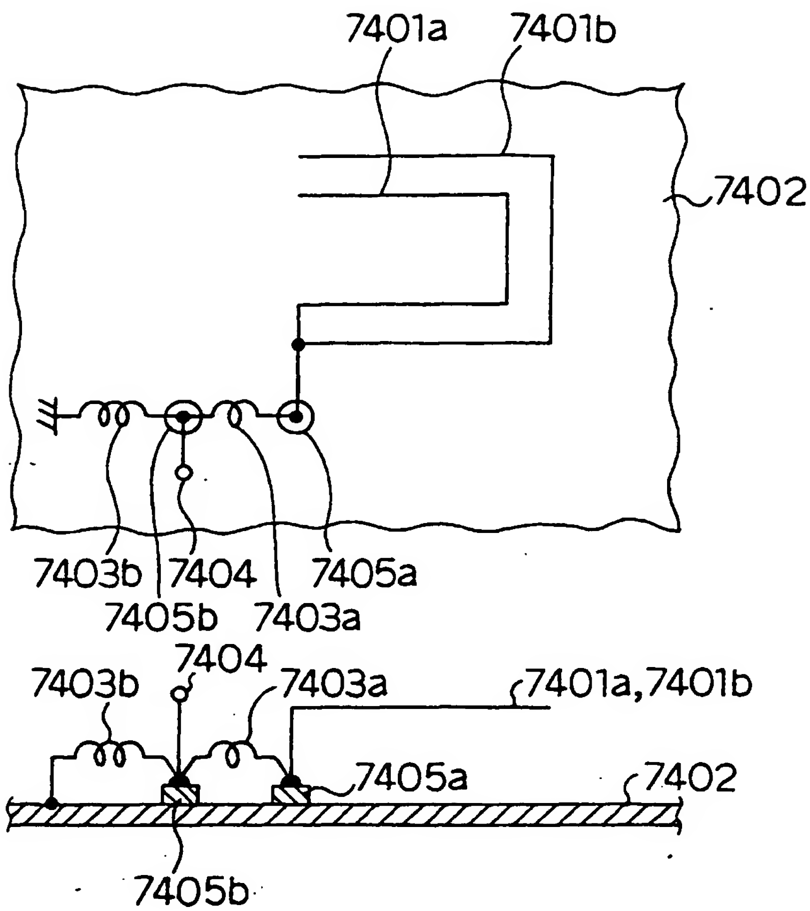
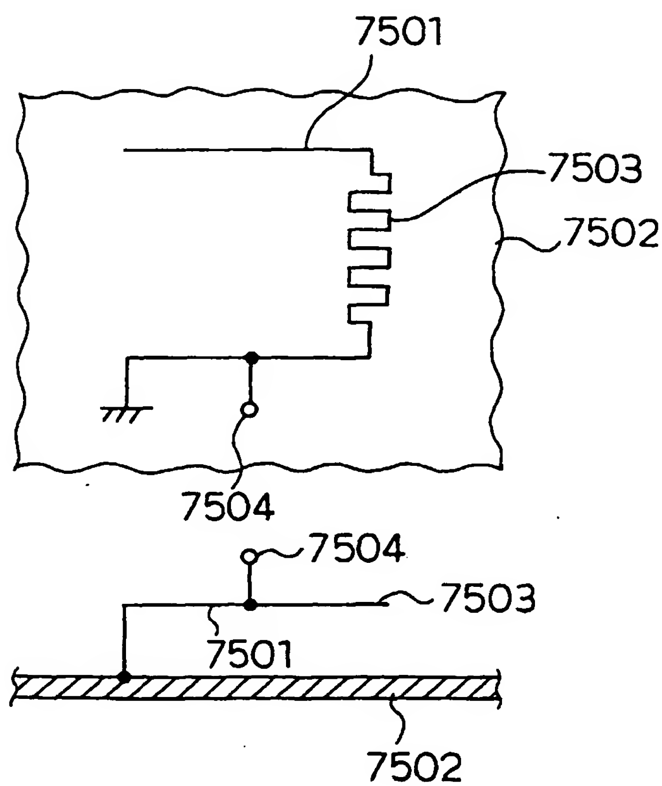

7401a
7401b
7402
7403b
7404
7405a
7405b
7403a
7403b
7404
7403a
7401a,7401b
7405a
7402
7405b

Fig. 75



F i g. 7 6

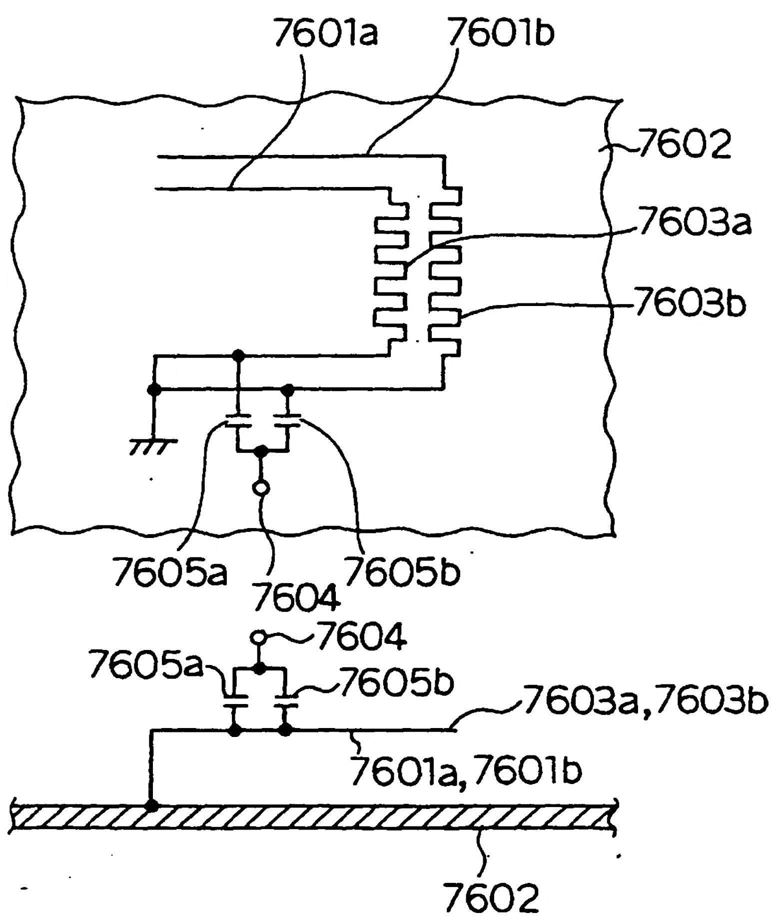

7601a
7601b
7602
7603a
7603b
7605a
7604
7605b
7604
7605a
7605b
7603a,7603b
7601a,7601b
7602

Fig. 77

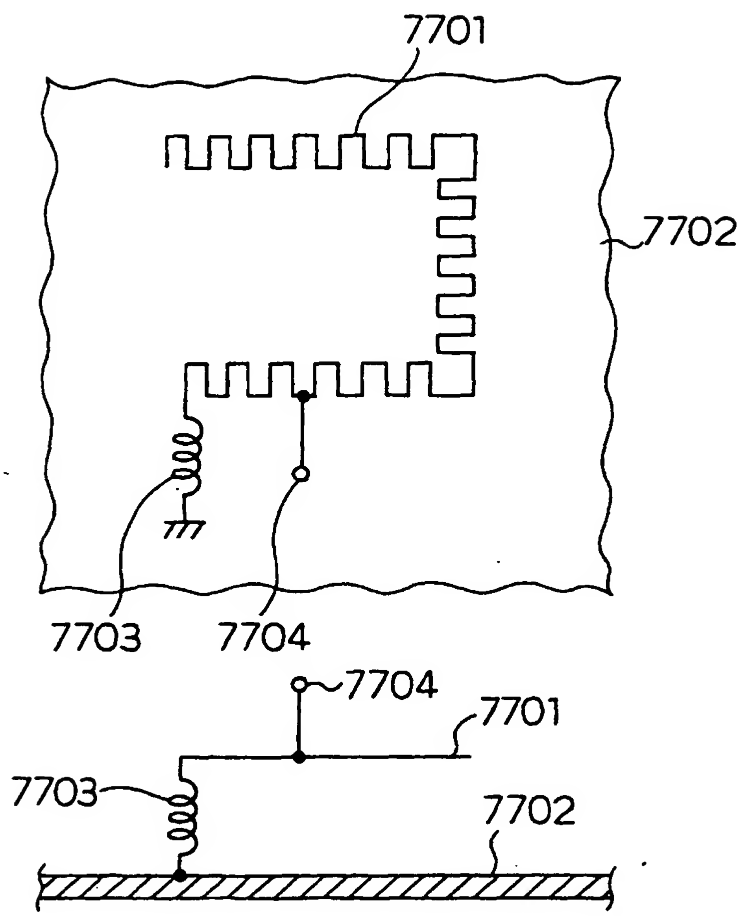


Fig. 78(a)

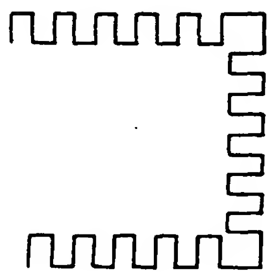


Fig. 78(b)

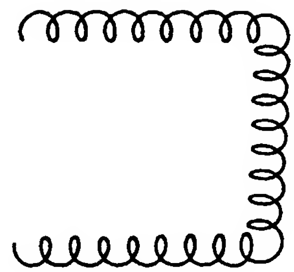


Fig. 78(c)

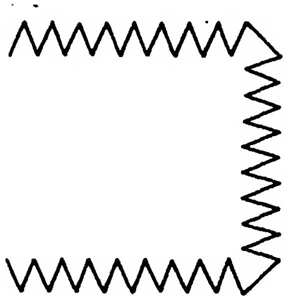


Fig. 79

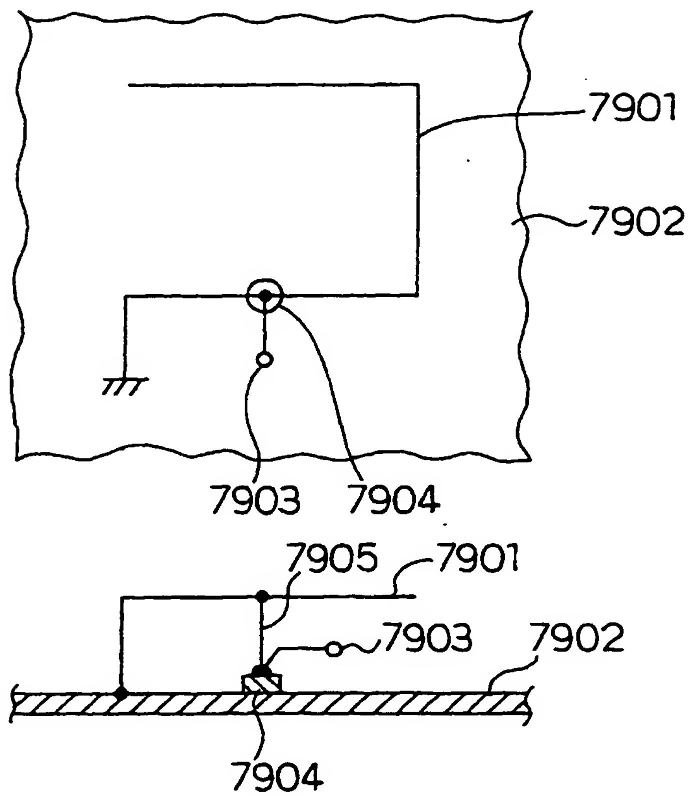


Fig. 80

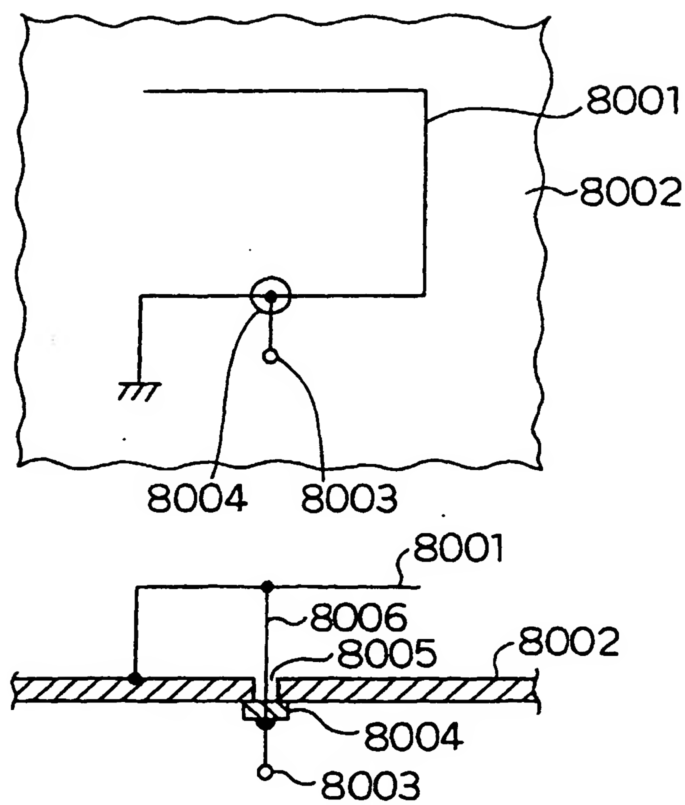


Fig. 81

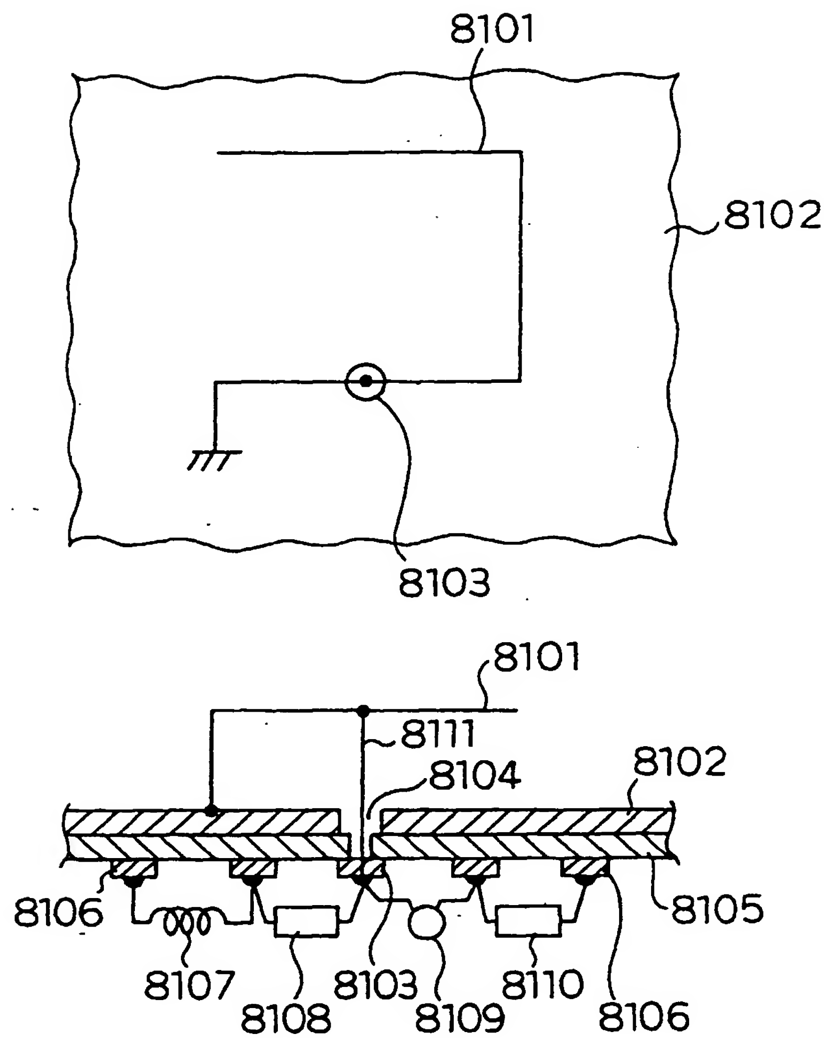

8101
8102
8103
8101
8111
8104
8102
8106
8105
8107
8108
8103
8109
8110
8106

Fig. 82

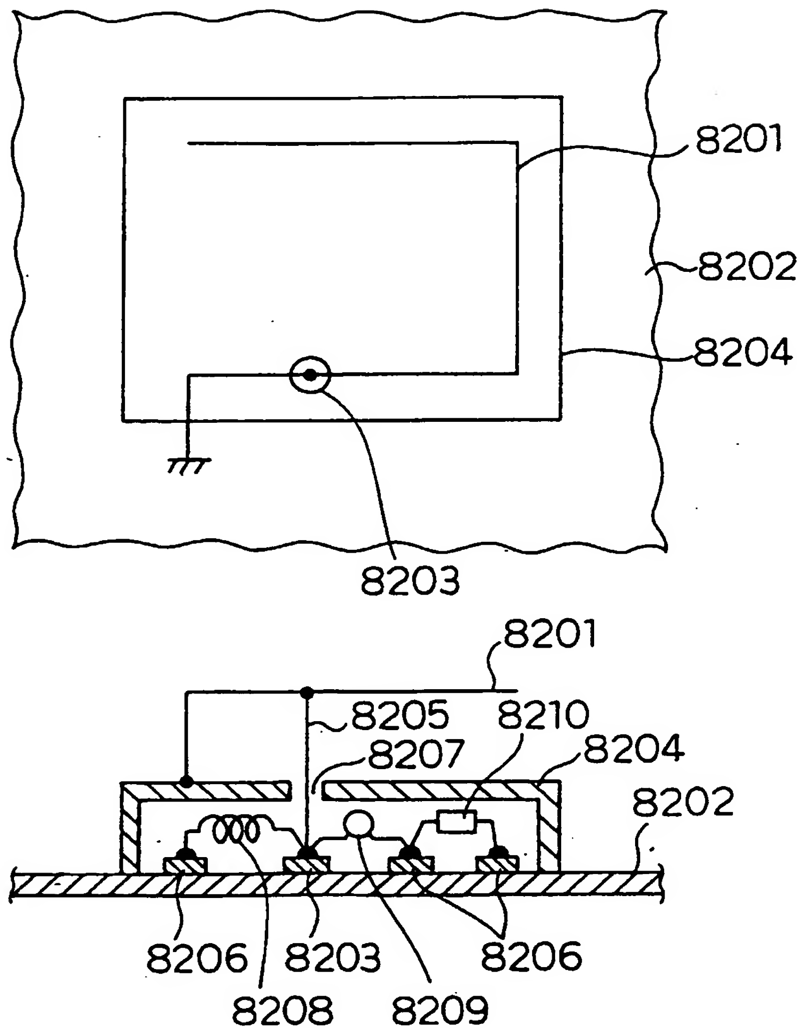

8201
8202
8204
8203
8201
8205
8210
8207
8204
8202
8206
8203
8206
8208
8209

Fig. 83

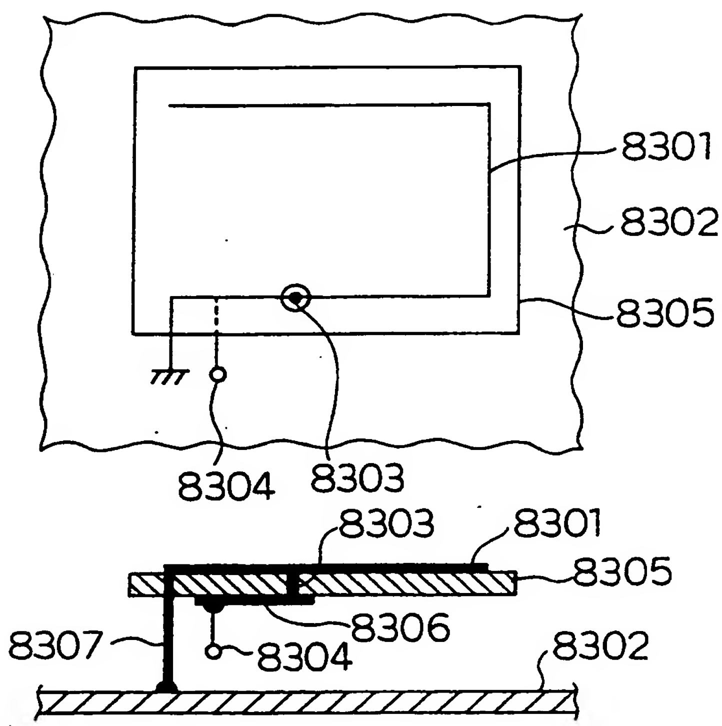


Fig. 84

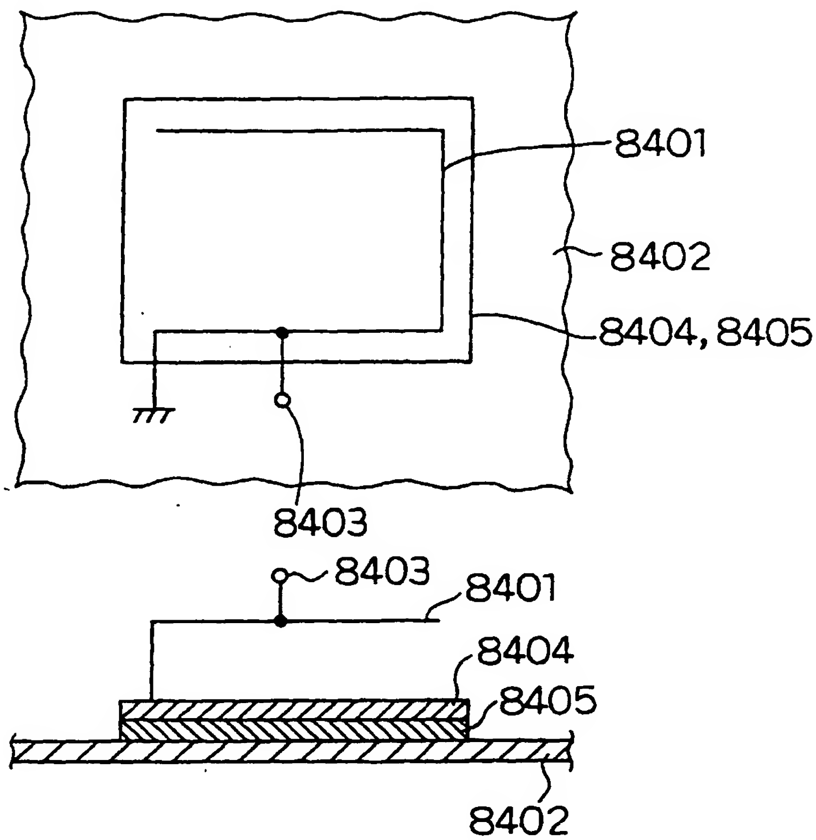


Fig. 85

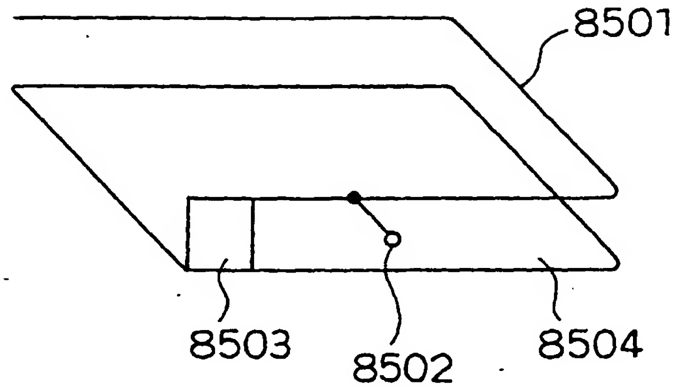


Fig. 86 (a)

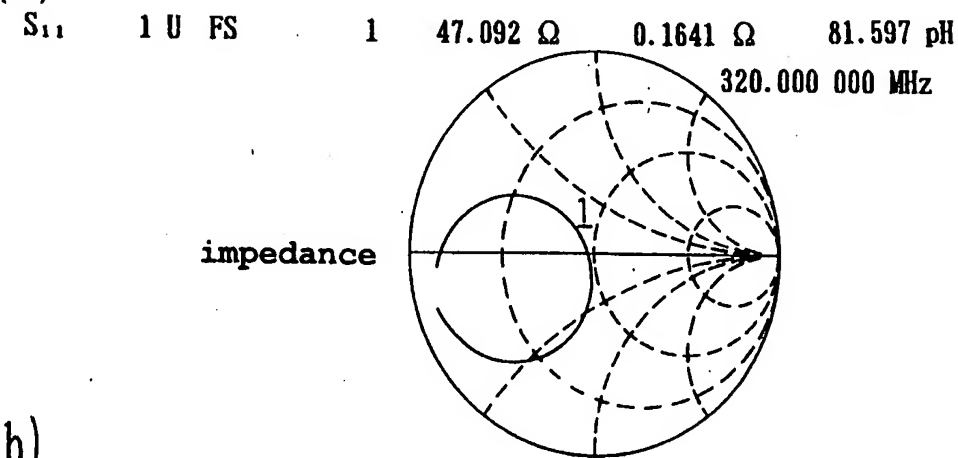


Fig. 86 (b)

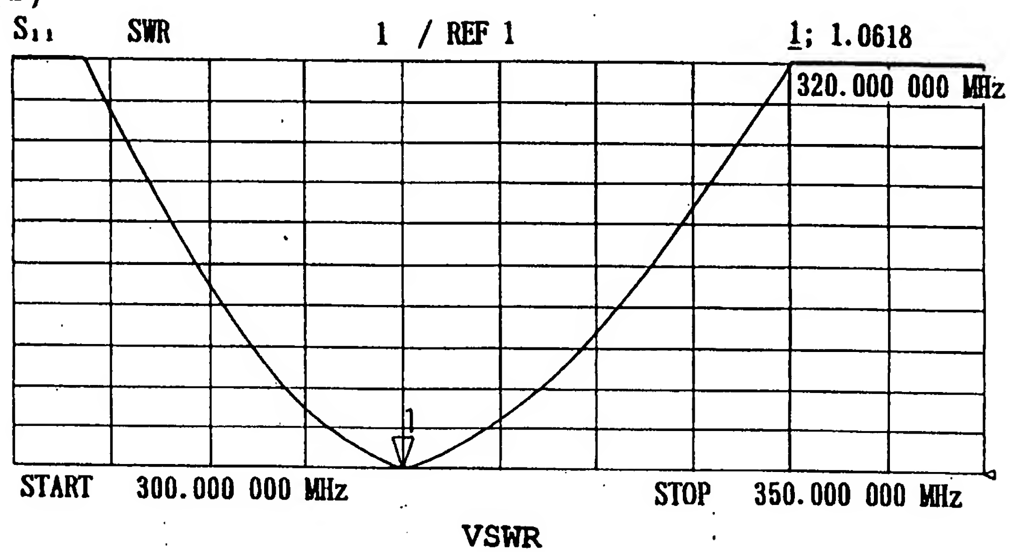
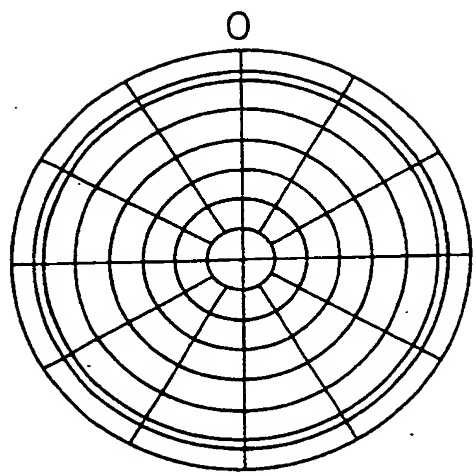


Fig. 87



vertical polarization wave

Fig. 88 VSWR of element(a) (196.5 MHz)

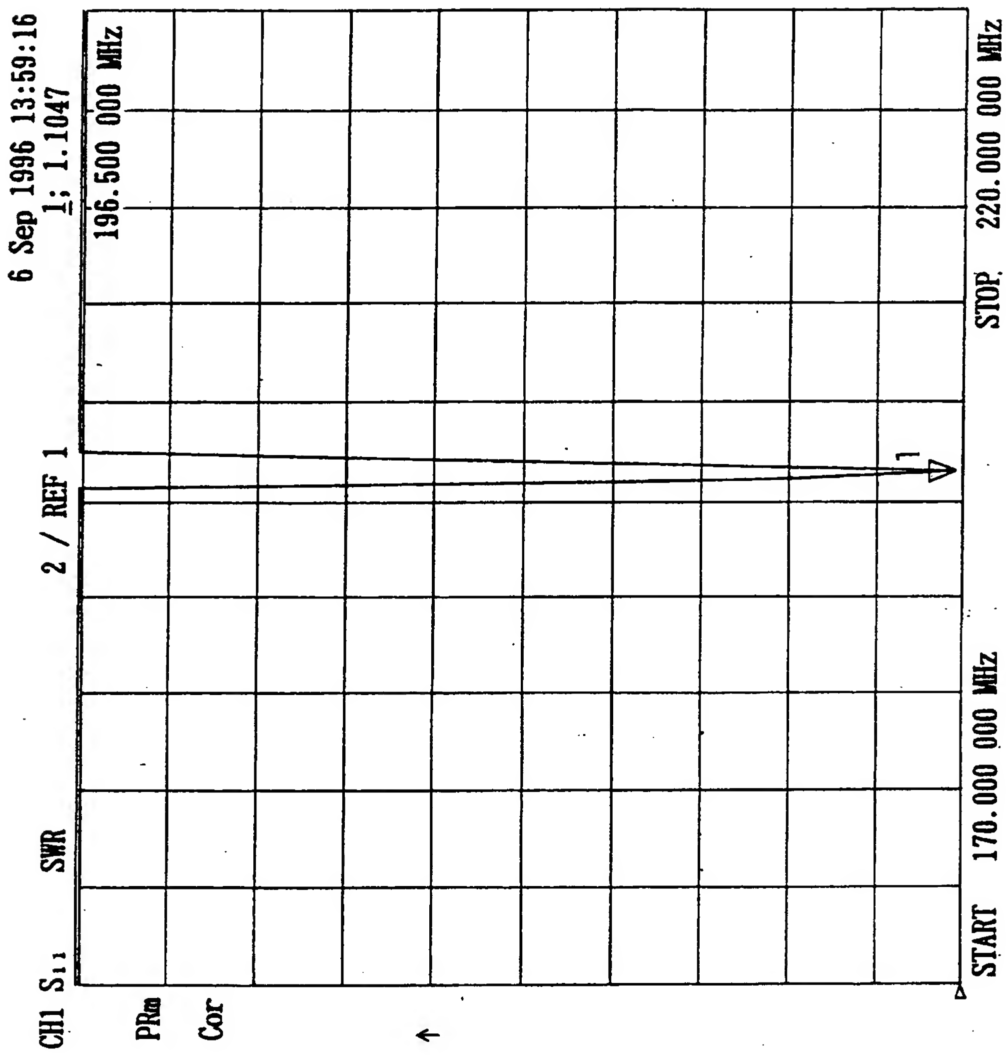


Fig. 89

VSWR of element(b) (198.75 MHz)

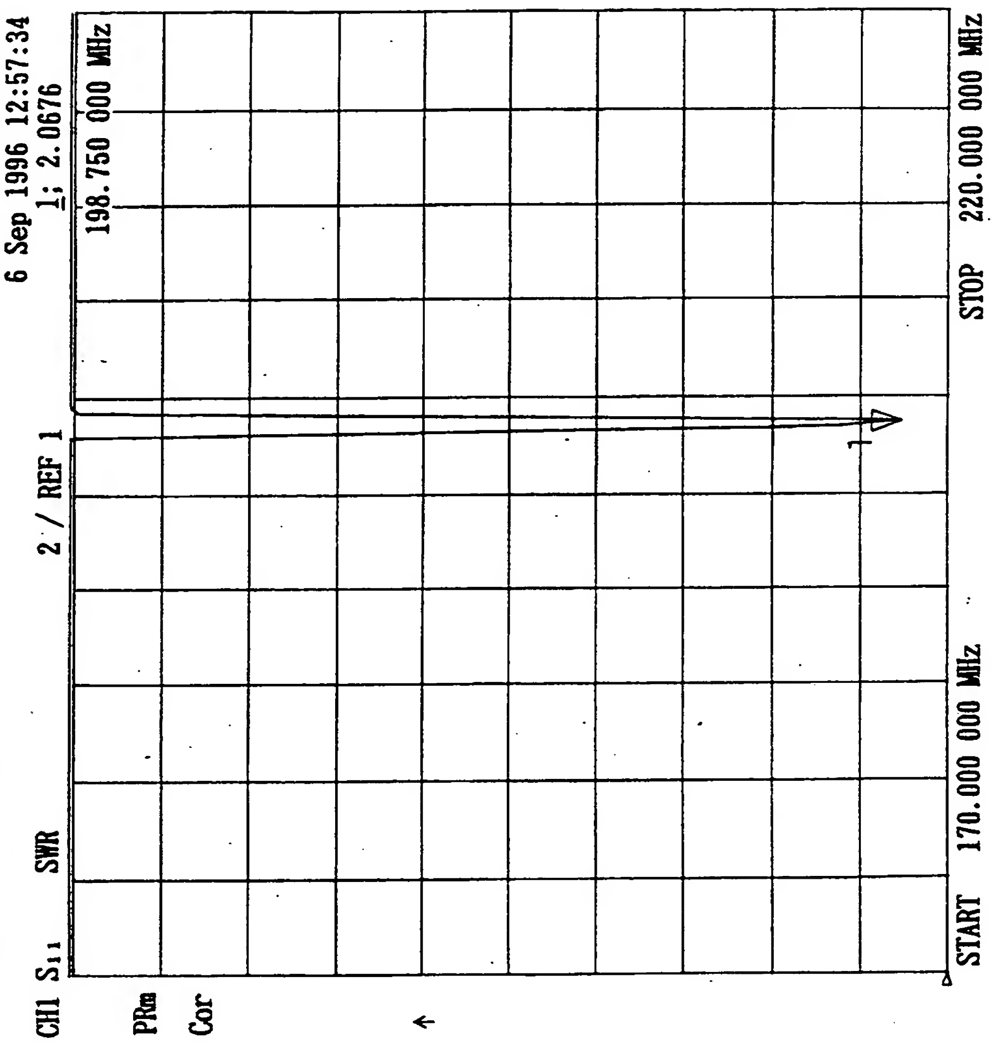


Fig. 90 VSWR of element (c) (200.5 MHz)

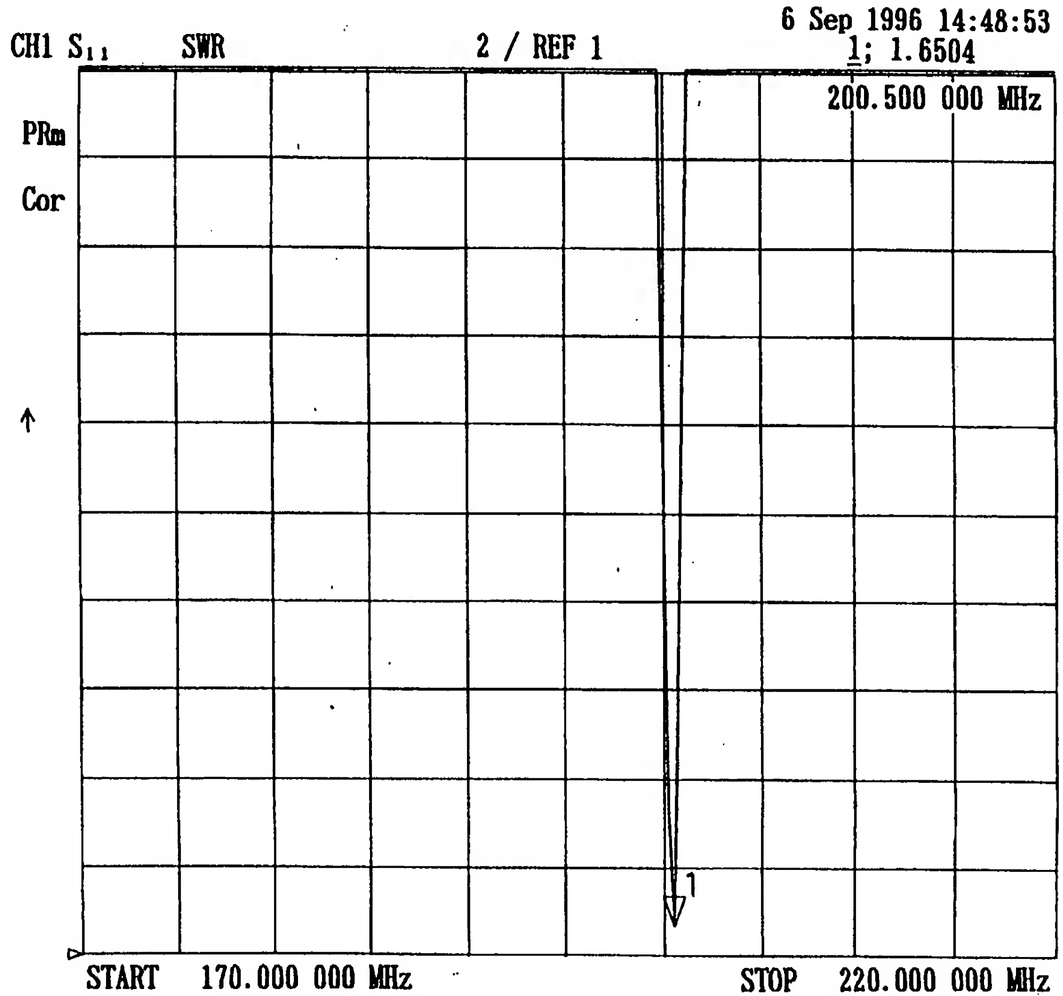


Fig. 91 VSWR of element(d) (203.75 MHz)

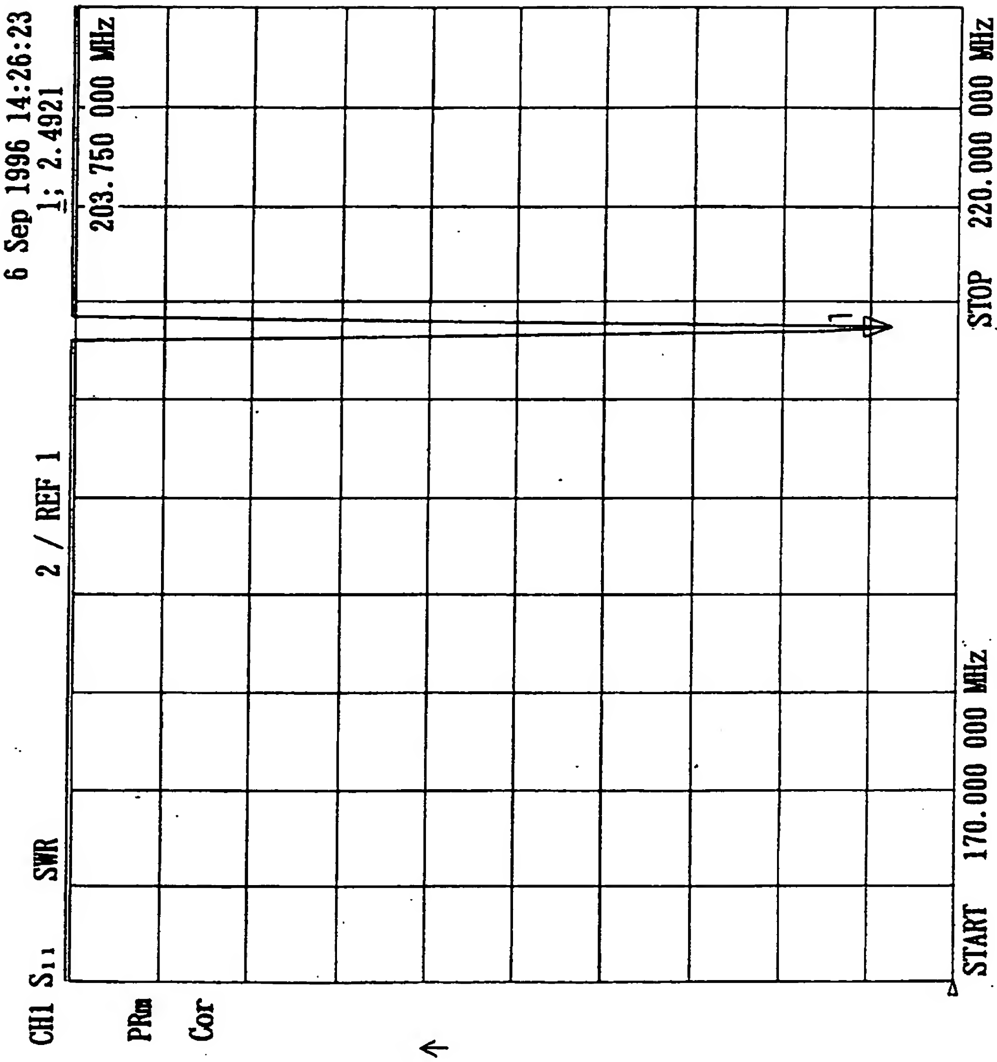


Fig. 92 No.1 (band composition VSWR of elements (a), (b), (c), (d))

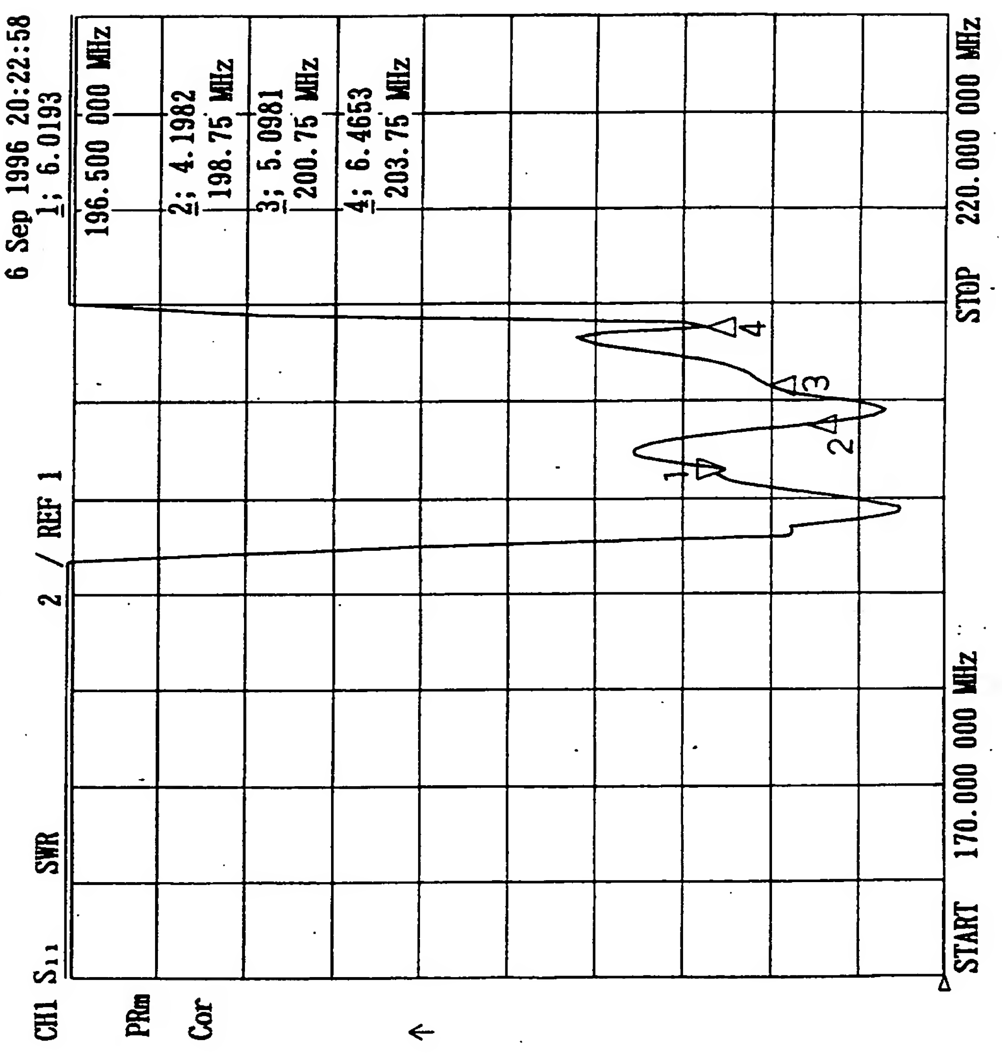
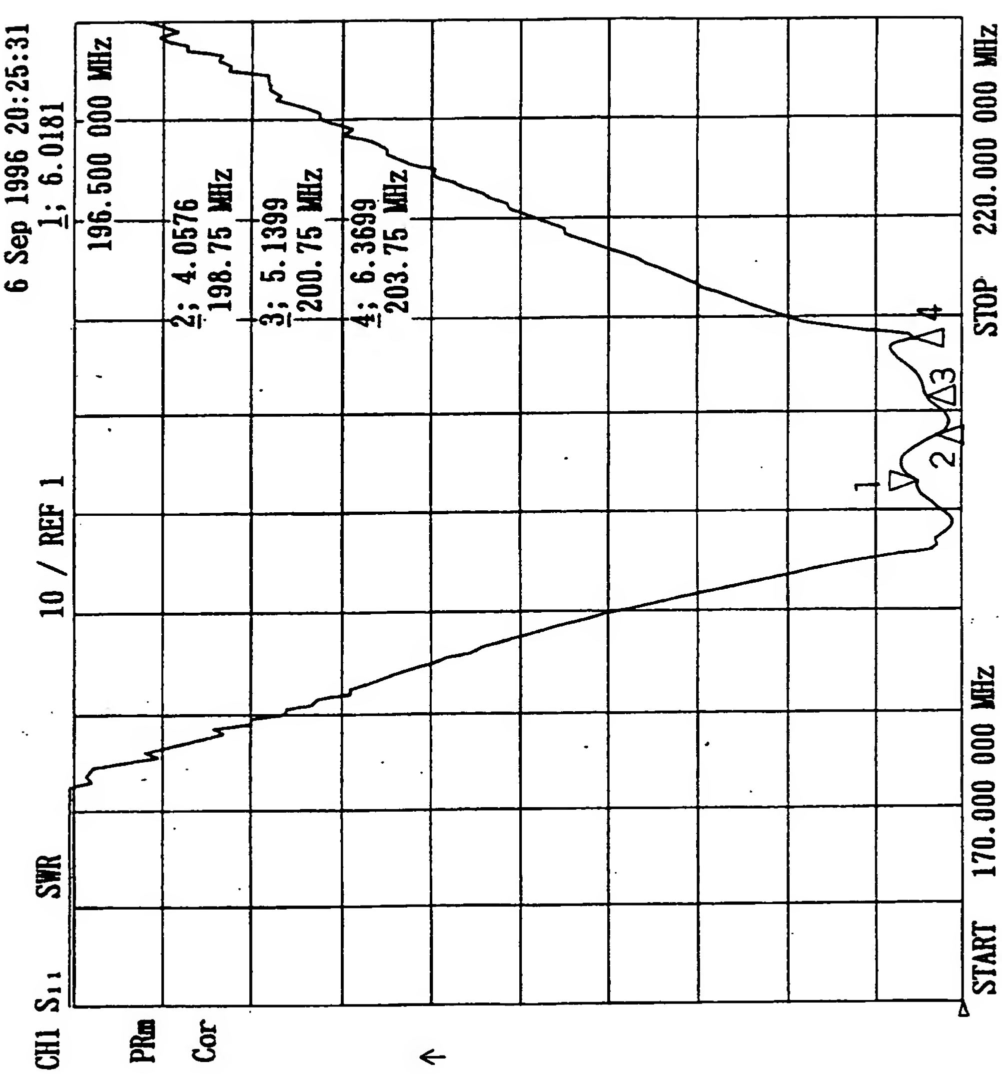
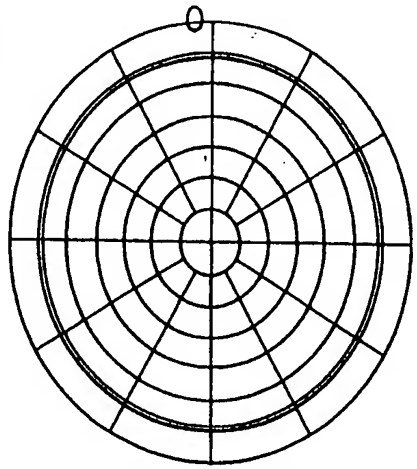


Fig. 93 No.2 (band composition VSWR of elements (a), (b), (c), (d))



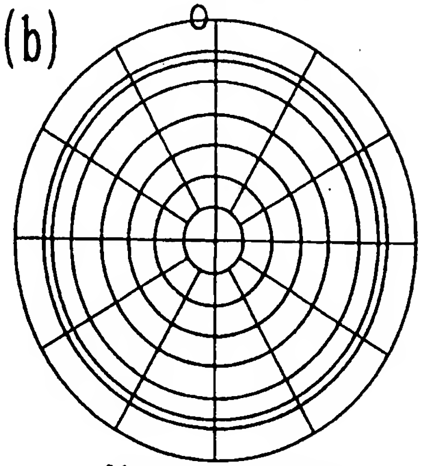
directional gain performance for vertical polarization wave

Fig. 94 (a)



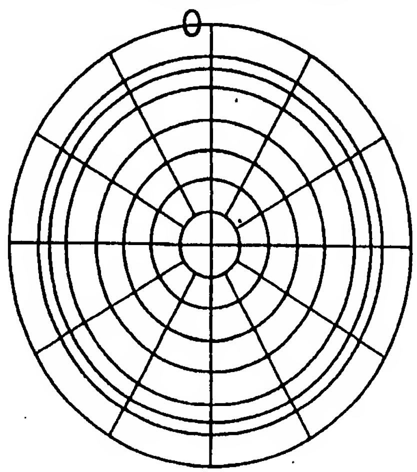
distance 10mm

Fig. 94 (b)



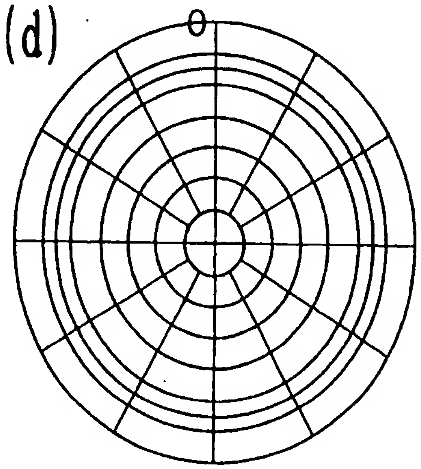
distance 30mm

Fig. 94 (c)



distance 80mm

Fig. 94 (d)



distance 150mm

Fig. 95

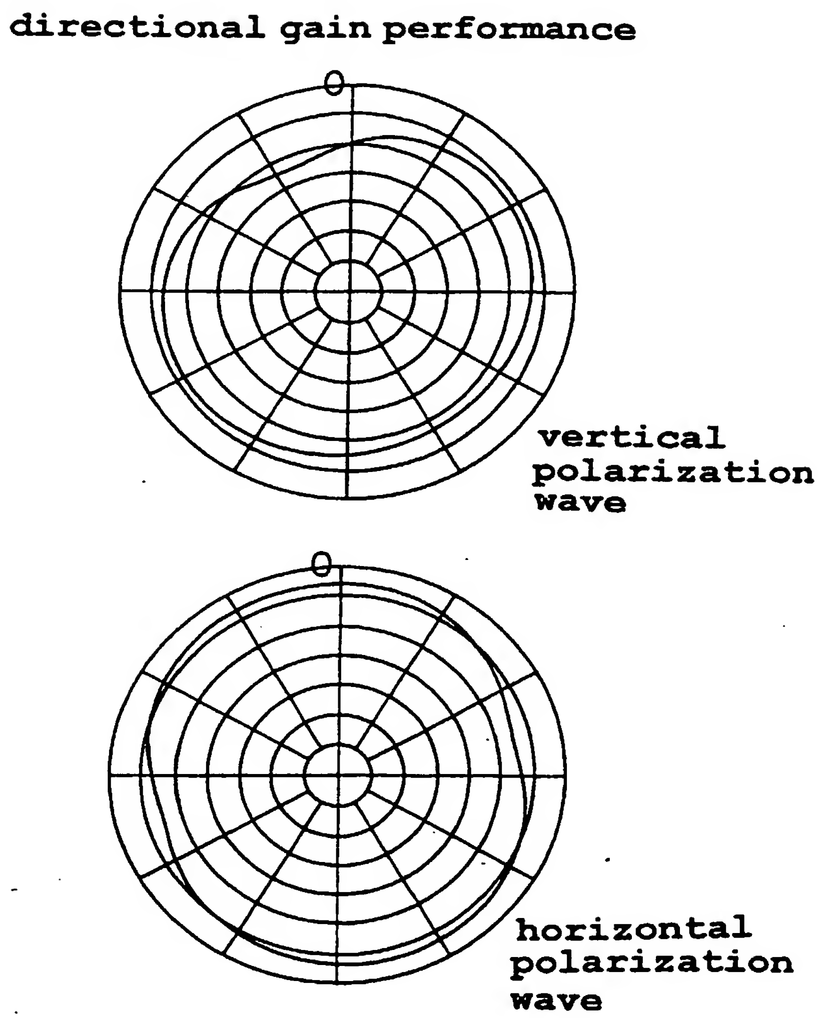
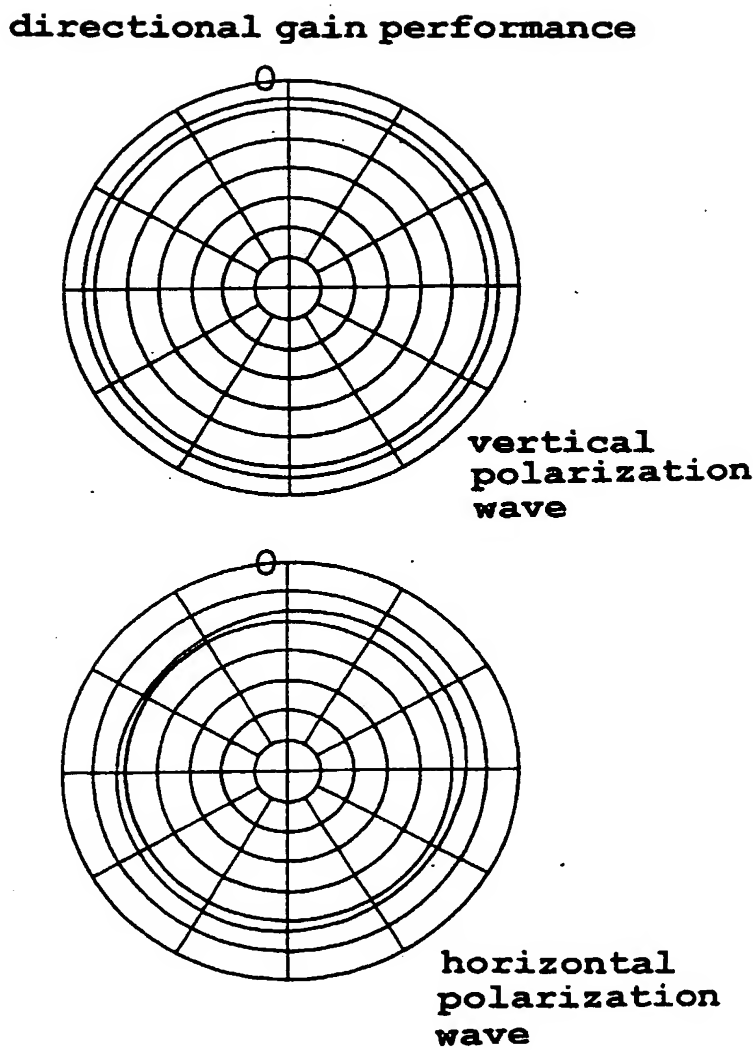

directional gain performance
0
vertical
polarization
wave
0
horizontal
polarization
wave

Fig. 96


directional gain performance
0
vertical
polarization
wave
0
horizontal
polarization
wave